Serial No. 084352
or
084353

INSTRUCTION MANUAL

MODEL 154-S-377
PROGRAMMABLE
WAVEFORM GENERATOR

Pull up resistors have been added to each programming line to eliminate the possibility of excess interface loading.

Change R5 on BD154 - 011 from 680Ω to 825Ω.

WAVETEK
Box 651, San Diego, Calif., 714-279-2200
619

Product Improvement Notice

Wavetek maintains a continuing program to make improvements to their instruments that will take advantage of the latest electronic developments in circuitry and components.

Due to the time required to document and print instruction manuals, it is not always possible to incorporate these changes in the manual.

Wavetek has manufactured your instrument, using metal film 1% tolerance resistors in place of 5% carbon resistors, wherever practical. This results in a substantial improvement in the overall performance of your instrument. Therefore, there may exist a discrepancy between the resistor used to manufacture your instrument and the resistor called out in the Parts List and Schematic Diagrams in this manual.

If field replacement of an affected resistor does become necessary, replacement may be made in accordance with the manual call outs. Wavetek, however, recommends replacement with the same type of resistor used in the manufacture of your instrument, whenever possible.

CONTENTS

SECTION 1 INTRODUCTION

1.1 GENERAL CAPABILITIES 1-1
1.2 PHYSICAL AND ELECTRICAL SPECIFICATIONS 1-1
1.3 PROGRAMMING 1-2

SECTION 2 INSTALLATION AND OPERATION

2.1 MECHANICAL INSTALLATION 2-1
2.2 ELECTRICAL INSTALLATION 2-1
2.3 OPERATING CONTROLS 2-1
2.4 INSTALLATION CHECKS 2-4
2.5 OPERATING PROCEDURE 2-5

SECTION 3 CIRCUIT DESCRIPTION

3.1 GENERAL DESCRIPTION 3-1
3.2 THEORY OF OPERATION 3-2

SECTION 4 CALIBRATION AND MAINTENANCE

4.1 INTRODUCTION 4-1
4.2 ACCESS INSTRUCTION 4-1
4.3 RECOMMENDED TEST EQUIPMENT 4-1
4.4 CALIBRATION INSTRUCTIONS 4-1
4.5 CORRECTIVE MAINTENANCE 4-4

SECTION 5 DIAGRAMS, ADDENDUMS, AND PARTS LISTS

5.1 DIAGRAMS 5-1
5.2 ADDENDUMS 5-1
5.3 PARTS LISTS 5-1
5.4 RECOMMENDED SPARE PARTS LIST . . . . . 5-2.

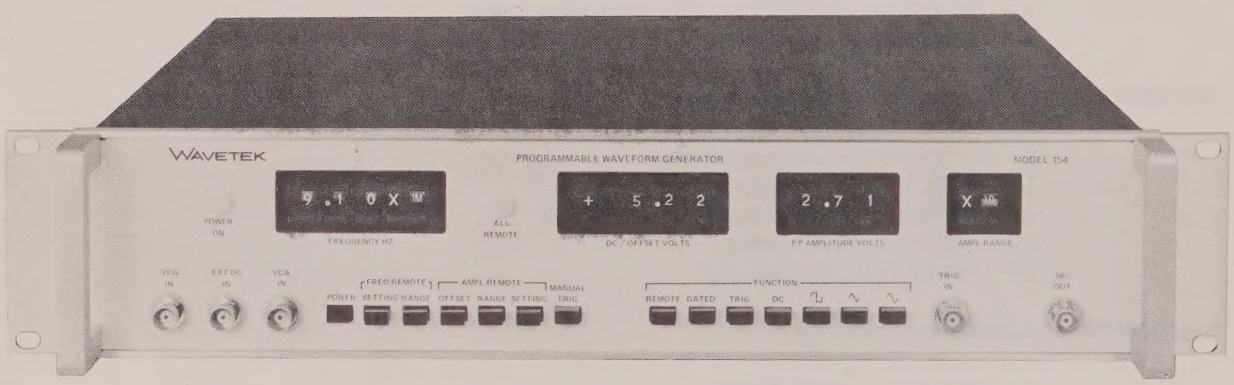


Figure i – Model 154 Programmable Waveform Generator

SCOPE OF THIS MANUAL

This manual provides descriptive material and instructions for the installation, operation, maintenance, and repair of this instrument. Wavetek's product improvement program ensures that the latest electronic developments are incorporated in all Wavetek instruments by the addition of circuit and component changes as rapidly as development and testing permit. Due to the time required to document and print instruction manuals, it is not always possible to incorporate the more recent changes in the released manual. In this case, data will be found on engineering change sheets at the rear of the manual. If no change sheets are included, the manual is correct as printed.

SECTION 1
INTRODUCTION

1.1 GENERAL CAPABILITIES

The Model 154 Programmable Waveform Generator is a precision source of sine, square and triangle waveforms covering a frequency range from 0.001 Hz to 10 MHz. In addition, a calibrated, programmable dc voltage output is provided. Amplitude, frequency and dc level may be digitally programmed with three digit resolution. Amplitude, frequency and dc level may also be modulated by an analog control voltage. The generator may be operated in continuous, triggered or gated modes. All controls may be locally or remotely programmed. All programming is DTL/TTL compatible.

1.2 PHYSICAL AND ELECTRICAL SPECIFICATIONS

1.2.1 Versatility

Output Signals
DC voltage, Sine ∿ , Square ⊓ and Triangle △ selectable, with auxiliary pulse output.

Frequency Range
0.001 Hz to 10 MHz in 10 decade ranges, with 3 digit resolution.

Main Output
DC voltage, ±0.1 Vdc to 10 Vdc at 100 mA maximum. Output impedance less than 1Ω. ∿ , ⊓ , △ , 0.001 V peak to peak to 10 V peak to peak into 50Ω load. Output impedance 50Ω. All waveforms may be offset 5 V above or below ground level with 3 digit resolution and selectable polarity. Signal level plus offset voltage not to exceed ±7.5 V peak into 50Ω load.

Auxiliary Output
50% duty cycle pulse at generator frequency. Fixed amplitude, 0 to +6 V peak into open circuit (0 to 3 V into 50Ω).

Operating Modes
Continuous, trigger, or gated mode, selectable. The generator may be triggered to produce single cycles by pushbutton trigger or external trigger command. Any discrete number of cycles will be produced by applying a gate signal for the desired burst width when in the gated mode. Minimum voltage required for trigger = +3 V. 50 V can be applied without damage.

Analog Modulation Control
The frequency, amplitude and dc offset level of the generator can be independently controlled by an external voltage. The control can be dc programming or wideband modulation.

1.2.2 Accuracy

Horizontal Precision
Frequency accuracy of the generator, whether programmed manually with front panel switches or remotely by external digital programming:

0.001 Hz to 100 kHz	±(1% of setting +1 digit)
100 kHz to 1 MHz	±(1% of full scale)
1 MHz to 10 MHz	±(2% of full scale)

Vertical Precision
∿ and ⊓ Waves

0.001 Hz to 100 kHz	±(1% of setting +1 digit)
100 kHz to 1 MHz	±(2% of setting +1 digit)
1 MHz to 10 MHz	±(5% of setting +1 digit)

△ Wave

0.001 Hz to 10 kHz	±(1% of setting +1 digit)

Vertical precision stated is for X1 amplitude multiplier. For X0.1, X0.01 and X0.001 add 1% per step.

DC Voltage
±(1% of setting +1% of full scale).

DC Offset
±(1% of setting +1% of range).

1.2.3 Waveform Purity

Stability

Short term	±0.05% for 10 minutes
Long term	±0.25% for 24 hours

Percentages apply to frequency, amplitude and dc offset stability.

Time Symmetry
1% to 500 kHz.

Amplitude Symmetry
All waveforms to 500 kHz are symmetrical about ground within ±1% of range maximum p-p amplitude.

Sine Distortion

10 Hz to 100 kHz	Less than 0.5%
0.001 Hz to 1 MHz	Less than 1.0%
1 MHz to 10 MHz	All harmonics at least −28 dB

Square Wave
Auxiliary output better than 5 nanosecond rise and fall time with less than 5% aberrations. Main output better than 35 nanosecond rise time with aberrations less than 5% ±10 mV.

Triangle Linearity
Greater than 99%, 0.01 Hz to 100 kHz.

DC Voltage
Ripple and noise less than 10 mV rms with generator idle.

1.2.4 Analog Control Characteristics

Voltage Control of Frequency (VCG)
Up to 1000:1 frequency change with an external voltage input of 5 volts. The upper frequency is limited to maximum of selected range. VCG input impedance 3.3 kΩ.

VCG Response
Bandwidth 100 kHz limited by a slew rate of 2% of range per microsecond.

VCG Linearity

1.0 Hz to 100 kHz	±0.2% of full scale
0.001 Hz to 1 MHz	±0.5% of full scale

Voltage Control of Amplitude (VCA)
Full amplitude control with an external voltage input of ±5 volts. The control is bipolar, that is, the amplitude can be controlled from maximum through null to range maximum at inverted phase. VCA input impedance is 3.3 kΩ.

VCA Response
Bandwidth 100 kHz limited by a slew rate of 2% of range per microsecond.

VCA Linearity
1% of full scale.

Voltage Control of DC Offset
All waveforms may be offset above or below ground level by an external voltage. Sensitivity of the signal is +2 or −2 volts offset per volt input dependent on dc polarity selected. Input impedance is 3.3 kΩ. Signal level plus offset voltage not to exceed ±7.5 volts peak into 50Ω load.

DC Offset Response
Bandwidth 100 kHz limited by a slew rate of 2% of range per microsecond.

DC Offset Linearity
1% of full scale.

1.2.5 Environmental

Specifications apply at 25°C ±5°C. For operation from 0°C to +50°C, derate all specifications by a factor of 2. Instrument may be stored from −50°C to +80°C without damage.

1.2.6 Mechanical

Dimensions
19-inch rack mount panel, 3½ inches high, 16½ inches deep.

Weight
15 lb. net, 24 lb. shipping.

Power
105 V to 125 V or 200 V to 250 V; 50 to 400 Hz; less than 45 watts.

NOTES

All specifications apply for control settings from 1.00 to 9.99.

On 1 MHz range only X1 and X0.1 amplitude settings apply.

1.3 PROGRAMMING

Description
All functions may be remotely controlled by BCD logic level programming. Front panel push button switches can be used to select local (front panel) control or remote control. When all controls are in the remote position, a logic voltage output is enabled for computer verification as well as illumination of a front panel light for visual verification. Signal ground and program ground are isolated.

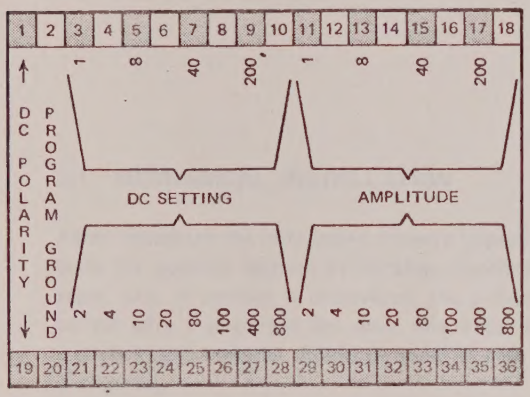
Program Requirements

Frequency	3 digits	12 lines
Frequency Range	10 ranges	4 lines
Amplitude	3 digits	12 lines
Amplitude Range	4 ranges	2 lines
DC Level	3 digits	12 lines
DC Polarity	0, + or −	2 lines
Function	∿ , ⊓ , ⩘ or dc	2 lines
Mode	Cont. Trig or Gate	2 lines
Output	Front or rear panel	1 line
Return		2 lines
All remote	Output for verification	1 line
Total No. of Lines for Complete Control		52 lines

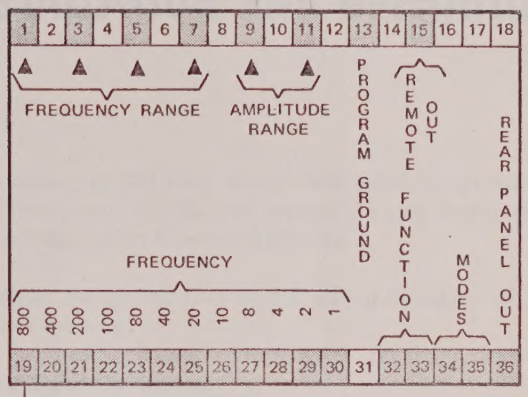
Program Transition Time
Frequency, amplitude and dc offset settings respond in less than 100 μs. Frequency range, function, offset polarity and attenuator respond in less than 3 ms.

CONTROL CONNECTOR PIN LAYOUT

Plug J2 — Mating Connector Amphenol 57-30360



Plug J3 — Mating Connector Amphenol 57-30360



15 kΩ (49 places)

+15 V

Standard Control Logic

Logic 1 = +2.4 V to +10 V, typical sink current 1.5 mA per line.

Logic 0 = −1 V to +1 V, open circuit voltage is approximately −0.7 V.

TRUTH TABLES WITH PIN ASSIGNMENTS

DC Polarity	Program (Pin No.) 19 1
+	0 0
0	0 1
−	1 0

Frequency Range	Program (Pin No.) 7 5 3 1
0.001	0 0 0 0
0.01	0 0 0 1
0.1	0 0 1 0
1.0	0 0 1 1
10	0 1 0 0
100	0 1 0 1
1 K	0 1 1 0
10 K	0 1 1 1
.1 M	1 0 0 0
1 M	1 0 0 1

Amplitude Range	Program (Pin No.) 11 9
0.001	0 0
0.01	0 1
0.1	1 0
1.0	1 1

Function	Program (Pin No.) 32 33
∿	0 0
∿	0 1
DC	1 0
⎍	1 1

Mode	Program (Pin No.) 35 34
Continuous	0 0
Gated	0 1
No Output	1 0
Trigger	1 1

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SECTION 2
INSTALLATION AND OPERATION

2.1 MECHANICAL INSTALLATION

After unpacking the instrument, visually inspect all external parts for possible damage to switches, connectors, surface areas, etc. If damage is discovered, file a claim with the carrier who transported the unit. The shipping container and packaging material should be saved in case reshipment is required.

The front panel has been designed to allow this unit to be mounted in a standard 19-inch equipment rack. No mechanical installation is required when the instrument is to be used as a portable bench unit.

2.2 ELECTRICAL INSTALLATION

2.2.1 Power Connection

NOTICE

Unless otherwise specified at the time of purchase, all Wavetek Model 154 instruments are shipped from the factory with the power transformer connected for operation on a normal 115-volt ac line supply, and a ½ amp 115-volt slow blow line fuse.

To convert to 230 volts, set the slide switch at the rear of the instrument to 230, and replace the fuse with a slow blow fuse rated at ¼ amp at 230 volts.

Connect the ac line cord to the mating connector at the rear of the unit.

2.2.2 Signal Connections

Use 50Ω shielded cables equipped with female BNC connectors to distribute all RF signals when connecting this instrument to associated equipment.

2.3 OPERATING CONTROLS

The operating controls and electrical connections for the Model 154 are shown in Figures 2-1 and 2-2. Each of the following paragraph numbers corresponds to a number appearing in Figure 2-1, front panel, and Figure 2-2, rear panel.

FRONT PANEL CONTROLS

1. **Power On Indicator** – The indicator is illuminated when the unit is on.

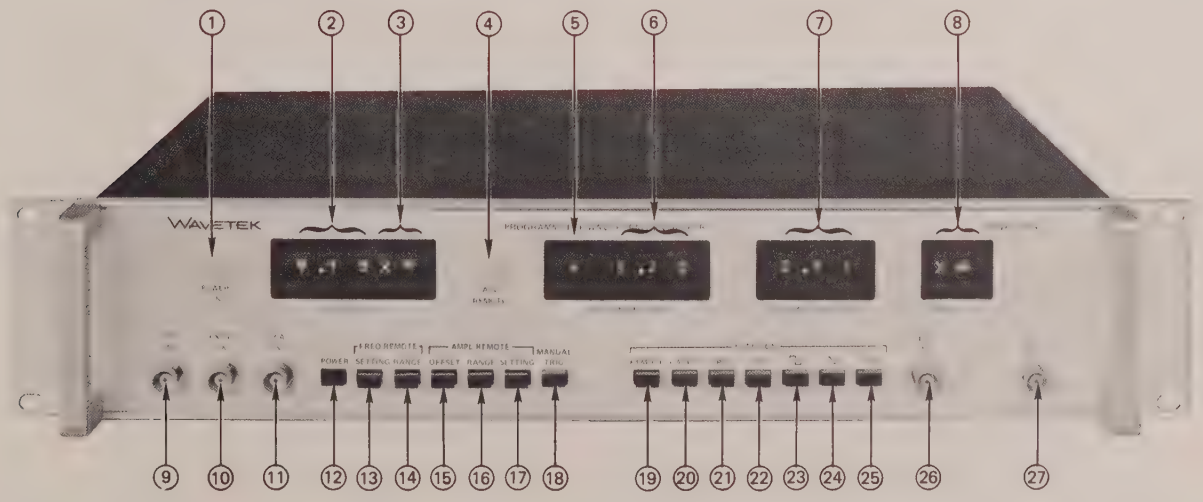


Figure 2-1. Operating Controls, Front Panel

2. **Frequency Hz Setting** — A three-digit thumbwheel switch is provided for output frequency selection. For the actual output frequency, this value is multiplied by the frequency Hz range multiplier (3).

3. **Frequency Hz Range Multiplier** — This thumbwheel switch has ten decade ranges from 1 millihertz to 1 megahertz. This value multiplied by the setting (2) gives the output frequency.

4. **All Remote Indicator** — When all the front panel remote push buttons are in (button Nos. 13, 14, 15, 16, 17 and 19, see Fig. 2-1), the indicator is illuminated. This means the generator is completely controlled by remote programming and independent of the front panel controls. In this condition a signal (> +3 Vdc) appears at pin 15 of plug J3 for computer notification.

5. **DC/Offset Polarity** — When in the dc mode, this switch determines the polarity of the dc level, either + or —. When in the "0" position, the dc level will always be zero. When in the ∿ , ⊓ , or ⩘ function, this switch controls the polarity of the offset. When in the "0" position, the offset will always be zero.

6. **DC/Offset Volts** — This three-digit thumbwheel switch sets the dc level when in the dc mode, or the amount of dc offset into a 50Ω load for the waveform functions. The maximum voltage of the output amplifier is limited to ±7.5 volts into 50 ohms; therefore, the peak signal amplitude plus the offset should not exceed this limit or a distorted waveform will be the result. When in the dc mode, the output dc voltage is dependent only on the setting of this switch and independent of the p-p amplitude volt and amplitude range settings and also independent of the load current up to 100 milliamps.

7. **P-P Amplitude Volts** — This three-digit thumbwheel switch is used to set the peak to peak signal level into a 50 ohm load. It controls the level for the sine, triangle and square waves, but has no control in the dc mode.

8. **Amplitude Range** — This switch has four ranges, 1.0, 0.1, 0.01, and 0.001, allowing output amplitudes from 9.99 volts to 1 millivolt.

9. **VCG IN (Voltage Controlled Generator)** — This connector allows external analog control of frequency. Up to a 1000:1 frequency change may be obtained. A positive voltage increases frequency and a negative voltage decreases frequency. See section under OPERATION for details.

10. **EXT DC IN (External DC Offset Control)** — This input allows external analog control of dc offset or of dc voltage output. Sensitivity of the input is +2 or —2 volts offset per 1 volt input dependent on dc polarity selected; i.e., a gain of two. The small signal bandwidth is 100 kHz and the slew rate is 2% of range per microsecond.

    The EXT DC IN connector operates in conjunction with any manually or remotely programmed dc level or offset. The signals will be added or subtracted depending on the polarities. If the polarity switch (see 5) is in the "0" position, the EXT DC IN connector is disabled.

11. **VCA IN (Voltage Controlled Amplitude)** — The output amplitude can be modulated by an analog voltage input to this connector. This input signal is algebraically summed with the p-p amplitude setting on the front panel or with the remote program. This input may be used for studying most amplitude modulation techniques.

12. **Power** — Depressing this push button switch turns the unit on.

13. **Frequency Remote, Setting** — The frequency setting (see No. 2) will be controlled by the remote program when this switch is depressed. This does not affect the range multiplier. The setting is 0.00 if the control lines are open and the switch is depressed.

14. **Frequency Remote, Range** — Depressing this switch causes the frequency range to be selected by the remote program. The range will stay at X0.001 if the control lines are open and the switch is depressed.

15. **Amplitude Remote, Offset** — When this push button switch is depressed, the dc voltage output or signal dc offset, including the polarity, is controlled by the remote program. The setting will be +0.00 if the control lines are open and the switch is depressed.

16. **Amplitude Remote, Range** — The amplitude range is remotely controlled when the push button switch is depressed. The range will stay at X0.001 if the control lines are open and the switch is depressed.

17. **Amplitude Remote, Setting** — Depressing this switch causes the amplitude setting to be controlled by the remote program. The setting will be 0.00 with the button depressed and the control lines open.

18. **Manual Trigger** — The manual trigger button operates when the generator is in either triggered or gated mode (see Nos. 20 and 21). In the triggered mode,

one cycle of the selected waveform is generated each time the button is depressed. In the gated mode, the generator will continue to oscillate while the button is depressed. Upon releasing the trigger button, the generator will complete the last cycle and stop oscillating.

19. **Function Remote** — When this button is depressed, all of the modes under the function heading (Nos. 20 - 25) are under remote control. If this switch is depressed and the control lines are open, the output waveform will be a sine wave in the continuous running mode.

20. **Gated Mode** — When this switch is depressed, the generator may be started by applying a gating signal of at least 3 volts to the TRIG IN connector (see No. 26). Removing the gating signal causes the generator to complete the last cycle and stop. The generator may also be gated by depressing the manual trigger button (see No. 18).

21. **Trigger Mode** — In this mode the generator will produce one cycle of output for each trigger signal applied. The frequency of the trigger signal should be lower than the generator frequency. The trigger signal must be at least 3 volts. If both the gated and trigger switches are depressed, the generator will be in the triggered mode.

22. **DC** — Depressing this button causes a dc output to be present at the 50Ω output connector (see No. 27). The output impedance in the dc mode is 1 ohm. The maximum amount of dc is 10 volts and is set by the dc volts thumbwheel switch (see No. 6). The polarity is determined by the dc polarity switch (see No. 5). The polarity must be + or — for an output. Neither the p-p amplitude (see No. 7) nor the amplitude range multiplier (see No. 8) control has any effect on the dc output. The loading current should not exceed 100 milliamps.

23. ⎍ **(Square Waveform)** — Depressing this button produces a square wave at the 50Ω output connector. Amplitude is controlled by the p-p amplitude volt and amplitude range switches (see Nos. 7 and 8), frequency by the frequency Hz setting and range multiplier switches (see Nos. 2 and 3).

24. ∿ **(Triangle Waveform)** — This switch applies a triangle waveform to the 50Ω output connector.

25. ∿ **(Sine Waveform)** — Depressing the button applies a sine wave to the 50Ω output connector.

26. **TRIG IN** — This connector accepts the trigger input signal for operation in either the trigger or gated mode (see Nos. 20 and 21). The trigger signal should be at least 3 volts. The input is dc coupled with 10K ohm impedance. Up to a 50 volt signal may be applied without damage.

27. **50Ω OUT** — This is the main output connector for all output signals. The signal will always be here unless the generator has been programmed to direct the output to the rear connector.

REAR PANEL CONTROLS

28. **AUX OUT** — This is an auxiliary pulse output. It is 0 to +6 volt pulse with 50% duty cycle. It can be used as a pulse, sync or squarewave output. It runs at the same frequency as the main generator. The rise and fall time is less than 5 nanoseconds.

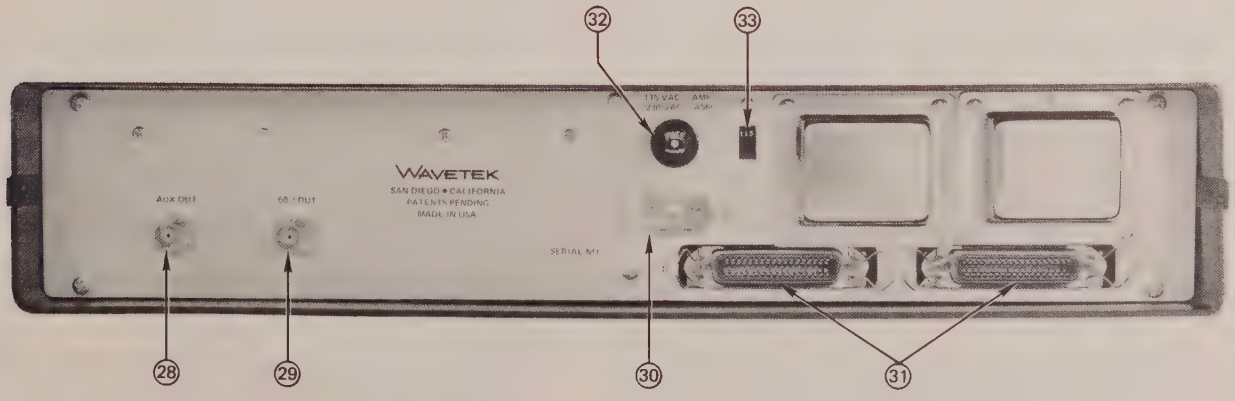


Figure 2-2. Operating Controls, Rear Panel

29. **50Ω OUT** – The main output is shifted to the rear output connector when pin No. 36 of connector J3 is programmed with a +2.4 V to +10 V signal. (See Section 1.3.)

30. **Power In Receptacle** – This connector accepts a female power cord for applying 120 or 240 volts ac.

31. **Remote Programming Connectors** – Remote control signals are input to the generator through these connectors. All control logic is BCD. (See Section 1.3 for pin assignments.) The mating connector (Part No. 57-30360) is manufactured by Amphenol.

32. **Line Fuse** – This fuse protects the instrument from ac line transients as well as shorts within the instrument. For 115 Vac operation, use a ½ amp slow blow fuse. For 230 Vac, use a ¼ amp slow blow fuse.

33. **115 - 230 Volt Switch** – This switch selects the power input voltage used. The instrument is normally shipped for 115 Vac and a ½ amp fuse. To convert to 230 Vac, set slide switch to 230 and install a ¼ amp slow blow fuse.

2.4 INSTALLATION CHECKS

This paragraph outlines a quick checkout procedure to determine if the instrument is operating properly. Field calibration and checkout instructions are given in Section 4 to determine compliance with electrical specifications. If electrical deficiencies exist, refer to the warranty on the back of the title page.

Use a Tektronix Model 454 oscilloscope (or equivalent) and a 10 MHz counter-timer with 4-digit resolution when performing these installation checks.

1. Connect the line cord to the ac line.

2. Connect the 50Ω OUT BNC to oscilloscope with 50 ohm cable terminated with 50 ohms.

3. Set frequency Hz to 1.00 X 1K.

4. Set DC/OFFSET VOLTS to 0 0.00.

5. Set P-P AMPLITUDE VOLTS to 1.00.

6. Set AMPL RANGE to X1.0.

7. Set generator up for complete manual control; that is, see that none of the remote buttons is depressed.

8. Depress ⊓⊔ push button.

9. Depress POWER push button.

10. Observe a 1 volt p-p square wave at 1 kHz on the oscilloscope.

11. Depress ⋀⋁ and then ∿ push buttons. Observe triangle and sine waveforms, respectively.

12. Depress TRIG push button. Press MANUAL TRIG button several times and observe single cycle generation. Return TRIG button to out position.

13. Depress GATED push button. The generator should run as long as the MANUAL TRIG button is depressed. Return GATED button to out position.

14. With FUNCTION still on ∿ and amplitude at 1.00 X 1.0, set DC/OFFSET VOLTS to +5.00. Rotate most significant decade from 5 to 0. Change polarity to –. Rotate same switch from 0 to 5. Observe sine waveform being offset, first positively, then decreasing to zero and then increasing negatively over the range of ±5 volts. See Section 2.3, number 6, for signal plus offset limitations on the output amplifier. Return DC/OFFSET VOLTS to 0 0.00.

15. Set P-P AMPLITUDE VOLTS to 9.99. Rotate most significant decade from 9 to 0 and note proper operation of amplitude setting control.

16. Return P-P AMPLITUDE VOLTS to 9.99. Rotate AMPL RANGE control through all positions and note 20 dB change in amplitude per step. Return AMPL RANGE control to X1.0.

17. Remove 50 ohm terminator. Reconnect scope. Depress DC push button. Set DC/OFFSET VOLTS to +9.00. Observe 9 volt dc level. Rotate most significant decade of DC/OFFSET VOLTS thumbwheel switch from 9 to 0 and observe dc level decrease. Set polarity to – and rotate the same digit from 0 to 9. Observe dc level increasing negatively. Return DC/OFFSET VOLTS to 0 0.00.

18. Disconnect output BNC cable to oscilloscope and reconnect to a counter with 50 ohm terminator.

19. Rotate frequency setting and range multiplier switches and observe counter to verify proper frequency calibration.

20. Remote programming may be checked by applying dc levels (+2.4 to +10 V) to the appropriate pins of plugs J2 and J3 to verify that the output is correct. Use the Truth Tables with Pin Assignments in Section 1.3 to

determine which pins must receive a signal for a specified output.

2.5 OPERATING PROCEDURE

No preparation for operation is required beyond completion of the initial installation checks given in paragraph 2.4 of this manual. It is recommended that a one-half hour warm-up period be allowed for the associated equipment to reach a stabilized operating temperature and for the Model 154 to attain stated accuracies.

2.5.1 Operation as a Function Generator

1. Properly terminate the 50Ω OUT connector with 50Ω ±1% termination.

2. Select the desired waveform either from the front panel push buttons or by the remote program. If the remote mode is used, the FUNCTION REMOTE push button must be depressed.

3. Set FREQUENCY HZ setting and range multiplier for desired output frequency. If a remote program is used, be sure FREQ REMOTE SETTING and/or RANGE push buttons are depressed as required.

4. Set P-P AMPLITUDE VOLTS and AMPL RANGE multiplier for desired output amplitude. If a remote program is used, depress either or both AMPL REMOTE RANGE and SETTING push buttons as desired.

5. A positive or negative dc offset may be applied to the waveform by setting the DC/OFFSET VOLTS to the desired level. The peak signal value plus the offset cannot exceed ±7.5 volts. If it is desired to control the offset by the remote program, the AMPL REMOTE OFFSET push button must be depressed.

2.5.2 Operation as a Voltage Controlled Generator

The VCG input connector can be used to externally control the frequency of the generator. If a positive voltage is applied to the VCG input terminal, the frequency will increase from the dial setting. A negative voltage will cause the frequency to decrease from the dial setting. The VCG range of the Model 154 is 1000:1. The nomograph of Figure 2-3 shows the characteristics of the VCG circuit. Column A gives the frequency setting, column B, the VCG voltage and column C, the resultant frequency of the generator.

The following are examples of setting up the generator for several ranges of frequency change.

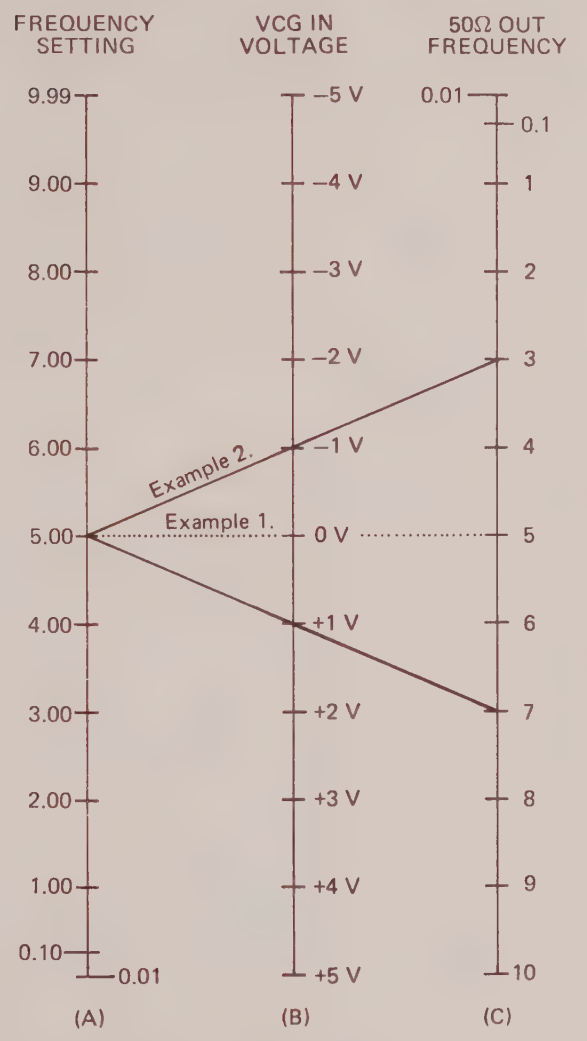


Figure 2-3. VCG Voltage-to-Frequency Nomograph

In example 1, the frequency setting is 5.00 and 0 volts VCG input voltage is applied. Extend a straight line from 5.00 (frequency setting) through 0 volts (VCG voltage). The result is an output frequency of 5 (multiplied by the range multiplier).

In example 2, the frequency setting is 5.00 and a varying VCG voltage of −1 V to +1 V is applied. By extending straight lines through the appropriate position it can be seen that the frequency will vary from 3 to 7 (multiplied by the range multiplier).

To obtain a maximum frequency change of 1000:1 the low frequency must have a setting of 0.01 X the multiplier. The maximum top frequency will then be 9.99 X the multiplier, thus giving a 1000:1 change.

For example, suppose an increasing sweep from 10 kHz to 10 MHz is desired. The VCG input must be a 0 to +5 volt ramp. The frequency setting must be 0.01 X 1M which equals 10 kHz (the low frequency). At a +5 volt input the generator will be at the full scale output (9.99 X 1M) or 10 MHz.

As another example, sweep down from 1 kHz to 1 Hz. The VCG input must be a 0 to −5 volt ramp. The frequency setting must be 9.99 X 100 which equals 1 kHz, the high frequency. At a −5 volt input the generator will be at the minimum allowed output for the X100 range (0.01 X 100) or 1 Hz. These examples may be verified by using the nomograph in Figure 2-3.

2.5.3 Operation as a Triggered Generator

1. Select the desired waveform by depressing the corresponding FUNCTION push button. If remote control is used, depress the FUNCTION REMOTE push button and program the remote connector as required.

2. Set or program generator to the desired frequency.

3. Depress the TRIG push button. If remote control is used, depress FUNCTION REMOTE. Apply +2.4 to +10 volt logic levels to pins 34 and 35 of plug J3. (See the Truth Tables in Section 1.3.)

4. Apply an external trigger signal of at least +3 volts to the TRIG IN connector or depress the MANUAL TRIG push button for generation of one cycle of the selected waveform. One cycle output will be generated for each input signal, providing the frequency of the trigger signal is lower than the generator frequency.

2.5.4 Operation as a Gated or Tone Burst Generator

1. Select the desired waveform by depressing the corresponding FUNCTION push button. If remote control is used, depress the FUNCTION REMOTE push button and program the remote connector as required.

2. Set or program generator to the desired frequency.

3. Depress the GATED push button. If remote control is used, depress FUNCTION REMOTE. Apply +2.4 to +10 volt logic level to pin 34. No signal is applied to pin 35.

4. Apply an external gating signal of at least +3 V to the TRIG IN connector or depress the MANUAL TRIG button. A gated or tone burst signal will be generated as long as gating signal is applied to TRIG IN or MANUAL TRIG is depressed.

2.5.5 Operation as a DC Voltage Source

Model 154 may be used as a calibrated dc voltage source not to exceed 100 mA of current as follows:

1. Set the generator in the triggered mode either by depressing the TRIG push button or by the remote program. See 2.5.3, Step 3. This inhibits the generator from running which minimizes the noise content of the dc.

2. Set the function to DC either locally or by remote program. The output impedance at the 50Ω OUT connector is now less than 1 ohm.

3. Connect the 50Ω OUT connector to the device under test.

4. Set or program the DC/OFFSET VOLTS to the desired value, either positive or negative. The dc voltage ranges from 9.99 to 0.01. The ripple and noise is less than 10 mV with the generator idle.

2.5.6 Operation as an Amplitude Modulated Generator

The VCA IN connector provides an input for amplitude modulation. In using the VCA capability of the generator, refer to Figure 2-4.

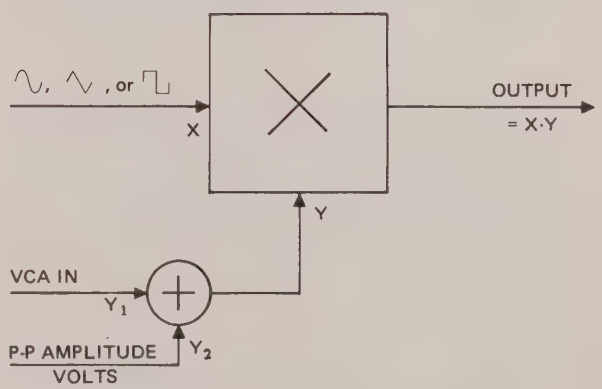


Figure 2-4. X-Y Multiplier Block Diagram

The output of the generator is the product of the X and Y inputs; that is, the generator signal times the sum of the VCA IN plus the p-p amplitude, or output = $X(Y_1 + Y_2)$. Y_2 is always a positive dc level, internal to the generator, which controls the output amplitude, if there is no VCA IN signal. Any VCA input, whether dc or ac, adds to Y_2. If the sum of Y_1 and Y_2 exceeds the output capabilities of the generator, a clipped waveform will result.

The modulated output of the generator with several different VCA input conditions is shown in Figure 2-5. The P-P AMPLITUDE VOLTS control is assumed to be 0.00.

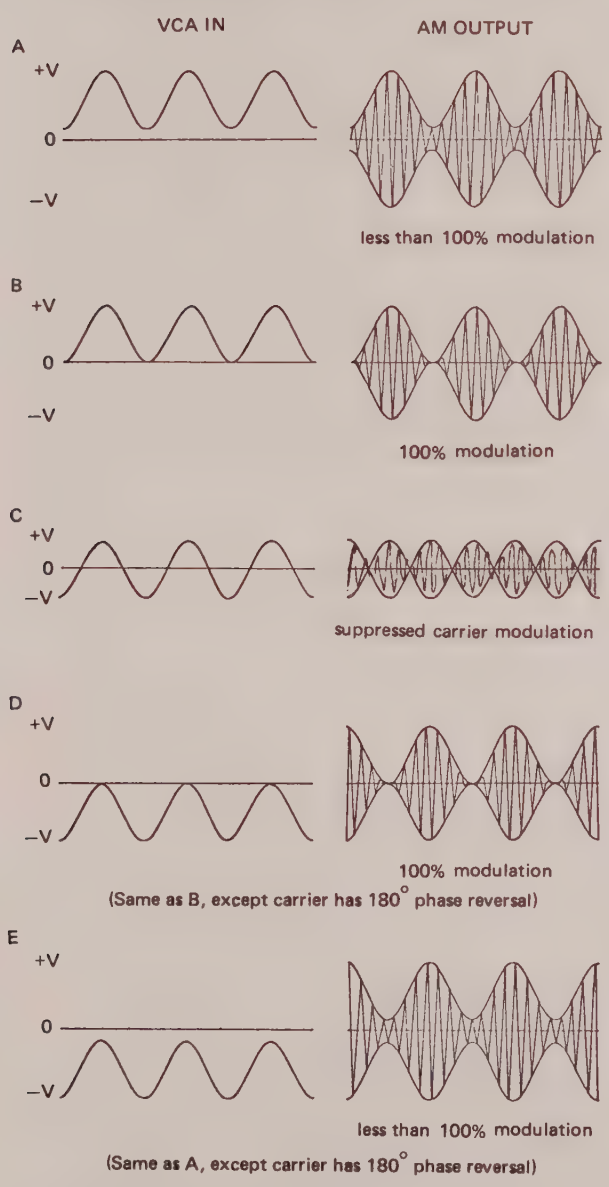


Figure 2-5. Amplitude Modulation Input and Resultant Output

The nomograph in Figure 2-6 is provided to determine the peak limits of the amplitude modulated output.

Example 1 displays suppressed carrier modulation. See Figure 2-5, Diagram C, for a display of the VCA input waveform and the resultant modulated output.

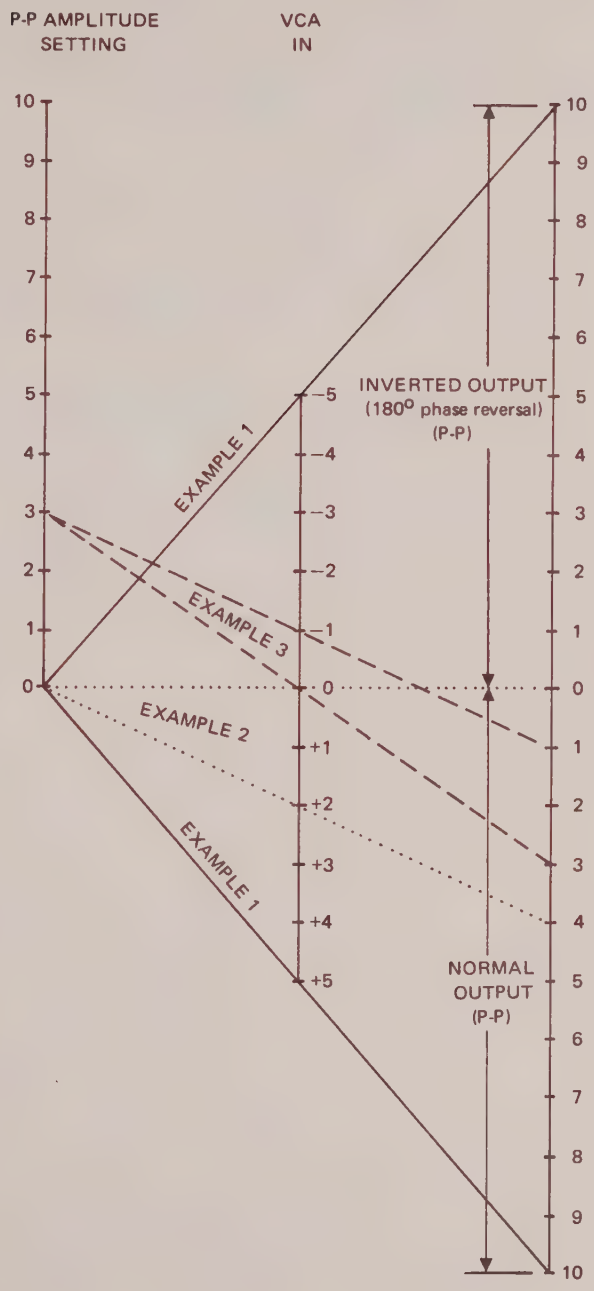


Figure 2-6. Amplitude Modulation Nomograph

Example 2 shows 100% modulation. The envelope is 4 volts peak to peak. The input sine wave is 2 volts p-p with the negative peak equal to zero as referenced to signal ground of the Model 154. See Figure 2-5, Diagram B, for waveform display.

Example 3 shows the effect of using the p-p amplitude control together with a VCA input. The result is less than 100% modulation, since the p-p amplitude control has offset the VCA input above signal ground. The effect is shown in Diagram A of Figure 2-5.

2.5.7 Remote Operation

The Model 154 may be partially or totally operated in the remote mode. Refer to Figure 2-1.

All of the following should be noted when using a remote program.

1. Be sure logic levels are compatible with those stated in Section 1.3.

2. Be sure plugs J2 and J3 are wired correctly according to the pin layout in Section 1.3.

3. Some or all functions may be programmed at any one time. See Section 2.3, paragraphs 13 through 19.

4. When the generator is completely under remote control, a front panel light will be illuminated as well as a signal generated at pin 15 of J3.

5. The analog program applied to the VCG IN, VCA IN and/or EXT DC IN are additive to the digital program.

6. The 50Ω OUT is normally at the front panel, but may be programmed to appear at the rear panel connector by applying a signal to pin 36 of connector J3. The waveform quality at high frequencies will be better at the front panel output.

CAUTION

At no time should voltage be applied to the instrument that will cause the potential between signal ground and program ground to exceed 10 Vdc.

SECTION 3
CIRCUIT DESCRIPTION

3.1. GENERAL DESCRIPTION

3.1.1 VCG Generator

A simplified block diagram of the VCG generator is shown in Figure 3-1. Triangle and square signals are generated simultaneously in the triangle generator circuit. The triangle is then applied to a sine converter and amplified.

The frequency is controlled by the current from the VCG amplifier which in turn is controlled by the voltage from the VCG D/A converter.

One of the signals, square, triangle, sine or DC, is fed into the X-Y multiplier and the amplitude is controlled by the VCA D/A converter.

The signal is then fed into the output amplifier. The amount of dc offset is controlled by the voltage from the dc offset D/A converter. The square wave from the triangle generator circuit is also fed into a fast switching circuit, a pulse amplifier, to generate a fixed amplitude fast square wave output.

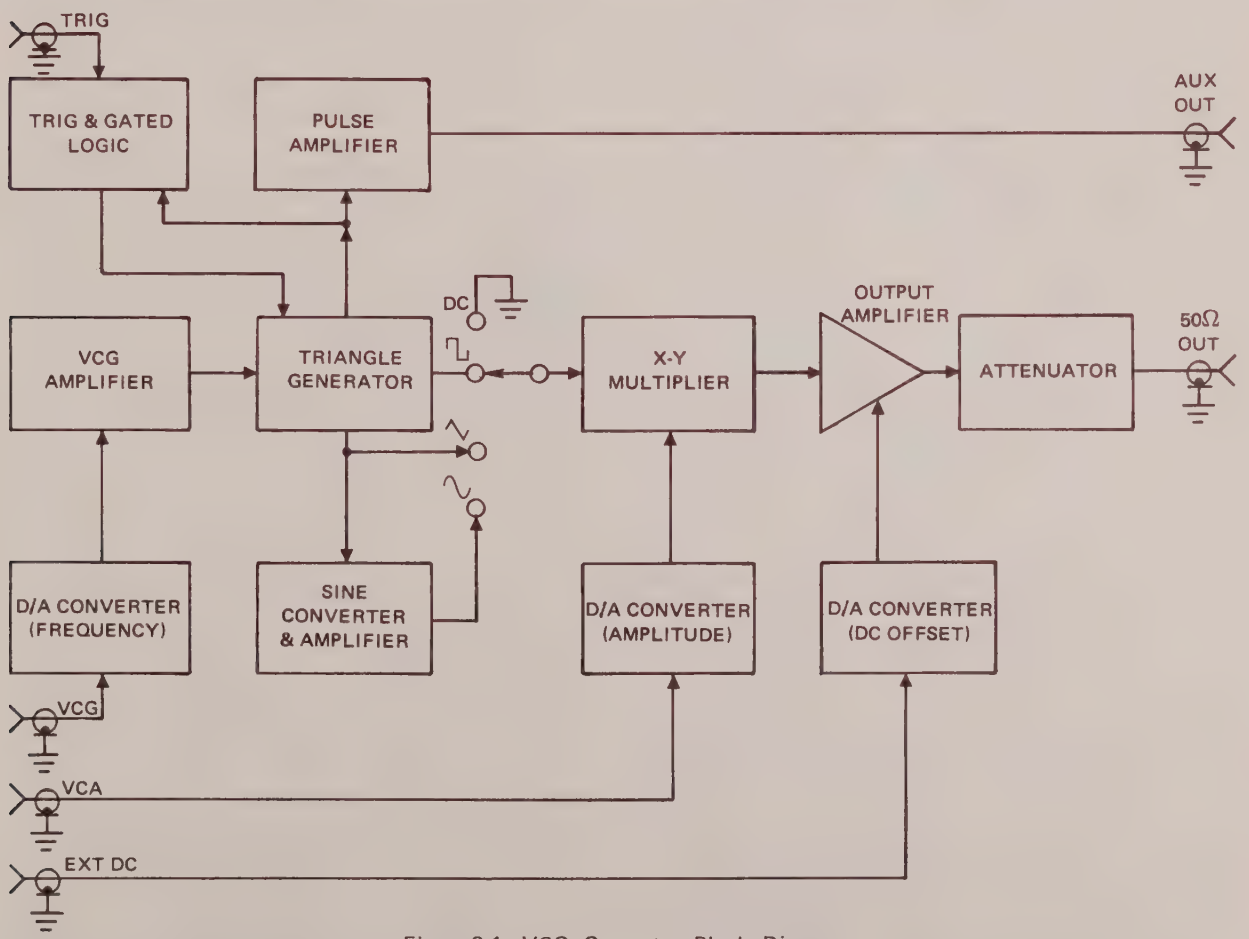


Figure 3-1. VCG Generator Block Diagram

3.2 THEORY OF OPERATION

3.2.1 Triangle Generator

When the voltage at point D is positive, the diodes CR15 and CR16 are reverse biased and CR14 and CR17 are forward biased. See Figure 3-2. Therefore, the current I+ is charging the capacitor C which causes the voltage at points A and B to rise. As soon as the voltage at point B reaches +1.25 V, the output of the hysteresis switch will switch negative and thus reverse the current flow. The current I− is drawn from capacitor C. Again, the hysteresis switch will switch positive when the voltage at B is below −1.25 V. Thus, triangle and square signals are generated simultaneously.

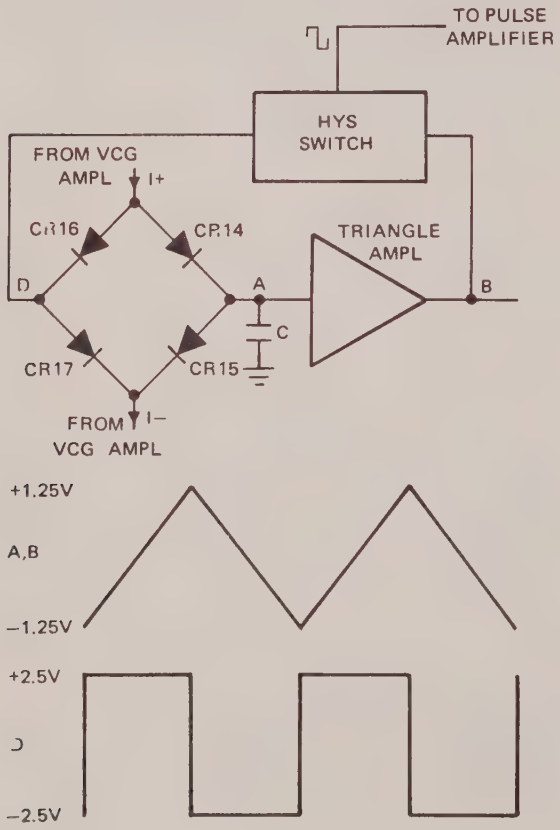


Figure 3-2. Triangle Generator Block Diagram

The output frequency depends on the size of the capacitor selected and the amount of currents, I+ and I−, charging the capacitor. The currents are controlled by the VCG amplifier which in turn is controlled by the voltage from the D/A amplifier and VCG input.

3.2.2 VCG Amplifier and Current Sources

The voltage used to control the output frequency from the D/A amplifier is applied to point A of the VCG amplifier. See Figure 3-3. Two ICs are used to shift the control voltage ground reference to the power supply reference. The other two ICs are the current source generators. The two current outputs are fed to the triangle generator.

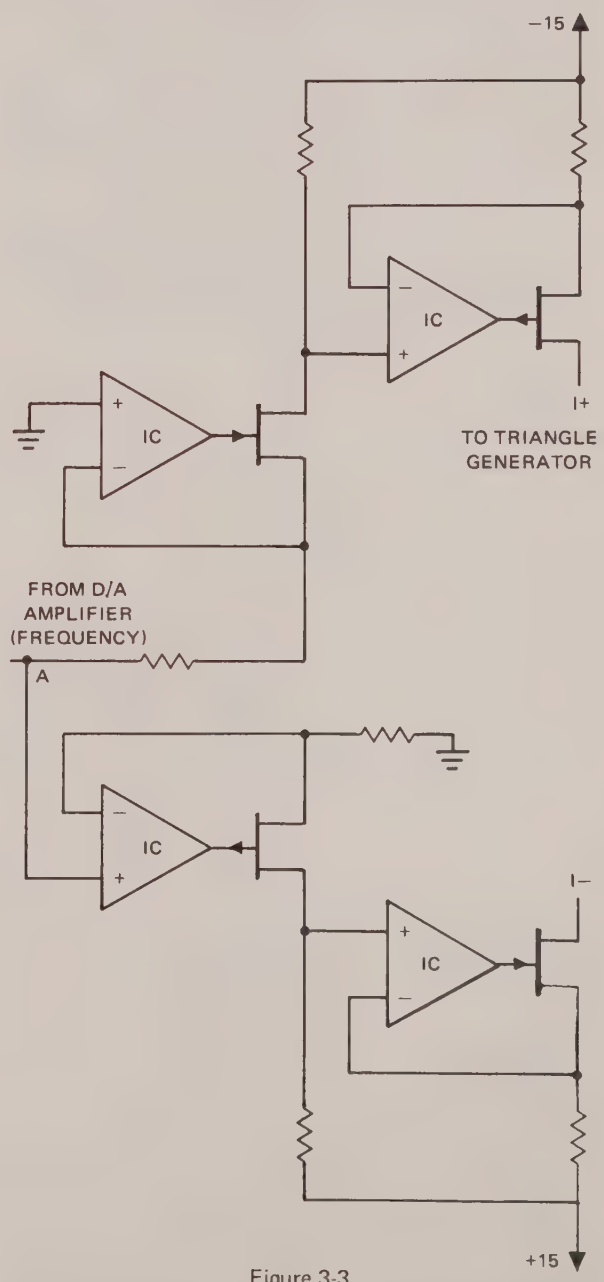


Figure 3-3.
VCG Amplifier and Current Source Simplified Circuit

3.2.3 Capacitance Multiplier

Frequency ranging is achieved by selecting different capacitors. For frequency ranges at X1 Hz or below, large capacitors are necessary and, therefore, impractical. Instead, a capacitance multiplier circuit is used, and ranging is achieved by changing the multiplication factor which is equivalent to the ranging resistors. The simplified circuit is shown in Figure 3-4.

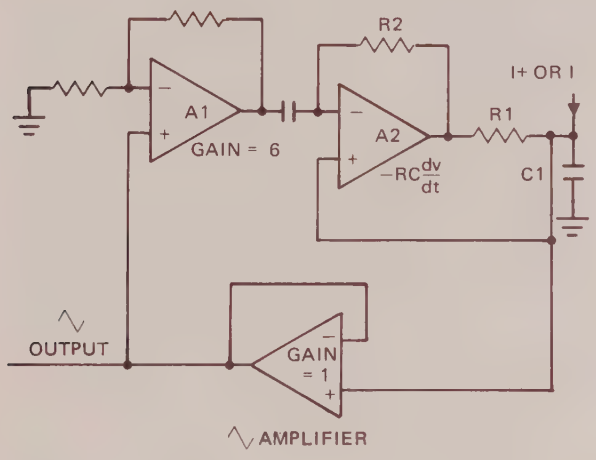


Figure 3-4. Capacitance Multiplier Simplified Circuit

Because of the nature of the feedback loop connection, A1 and A2, most of the current, I+ and I−, will be drawn by A2 through R1. Only a very small percentage of current is changing and discharging capacitor C1. Therefore, the output frequency will appear much slower. The percentage of current drawn by A2 is precisely controlled by the loop gain and time constant of the capacitance multiplier circuit. Frequency ranging is achieved by changing R2.

3.2.4 X-Y Multiplier and Output Amplifier

One of the signals is selected and fed into one input of the X-Y multiplier, and a control voltage from the D/A amplifier is fed to the other input. Refer to Figure 3-5. The differential output from the X-Y multiplier is directly proportional to the product of two inputs.

The signal is then fed into the output amplifier which consists of two inverting amplifiers. The combined operation of the two amplifiers is exactly equal to one differential amplifier. Because of the large common mode rejection of this amplifier, the output amplifier ground, " ⏚ ", can be floated from all other grounds, " ⏚ ". A separate power supply would be required in this case.

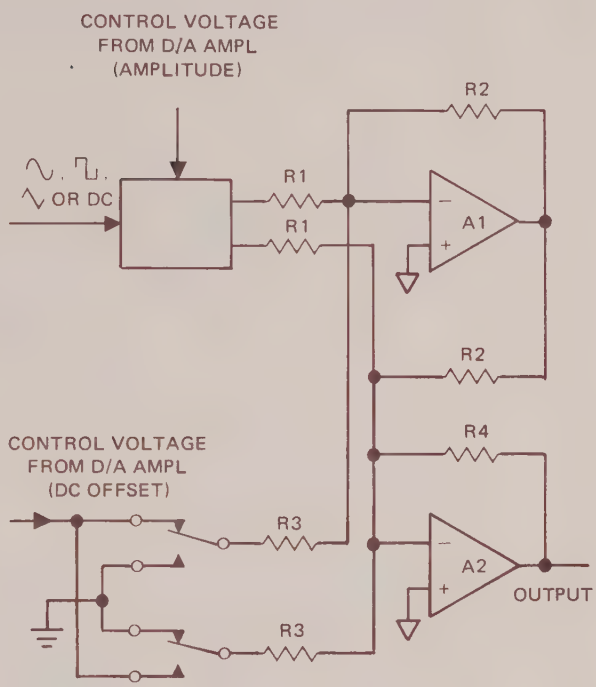


Figure 3-5.
X-Y Multiplier and Output Amplifier Simplified Circuit

3.2.5 Trigger Gated Modes

The triangle generator will oscillate continuously only if the voltage at **G** is negative which reverse biases CR11. Refer to Figure 3-6. This requires that the voltage at **E** or **F** be negative. If both voltages at **E** and **F** are positive, then so is the voltage at **G**. The current through CR11 will keep the voltage of **C** from falling below zero, because CR12 is clamped at zero. This stops the generator from oscillating.

The JK flip-flop is used to control the timing so that the triangle will always stop at the end of the cycle. The triangle will stop at time t_3, if the trigger signal is reset between times t_1 and t_3 as shown in the timing diagram.

If the signal at **B** is differentiated before it is applied to the JK flip-flop, only one cycle of the triangle signal will be generated for each trigger input.

3.2.6 D/A Converter

Diode gates are used to switch the voltage through weighting resistors into the summing node of an amplifier. Refer to the D/A Converter Schematic.

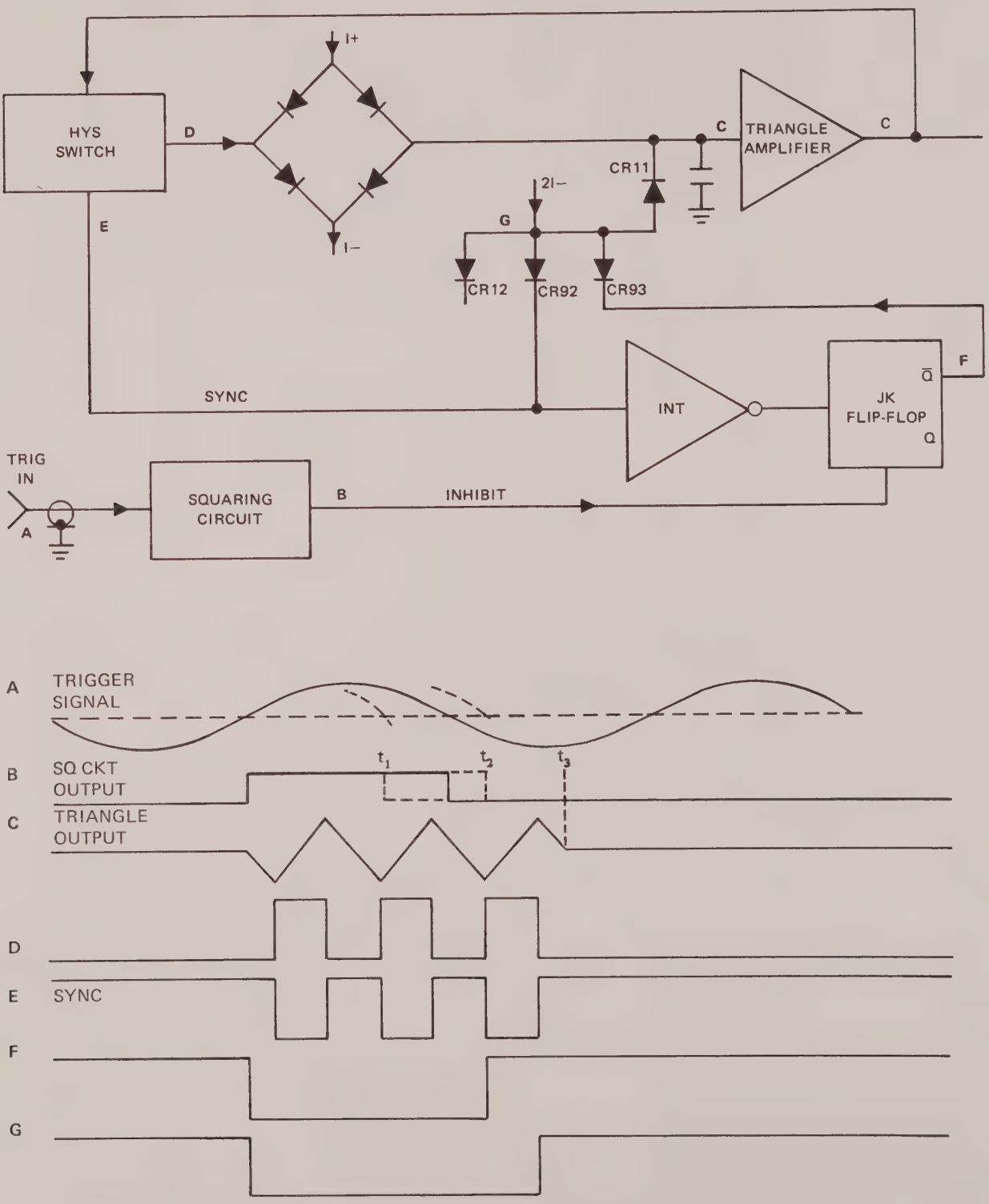


Figure 3-6. Trigger Gated Block and Timing Diagrams

SECTION 4

CALIBRATION AND MAINTENANCE

4.1 INTRODUCTION

This section provides instructions for testing, calibrating, troubleshooting, and repairing the Model 154 generator. The instructions are concise and written for the experienced electronics technician or field engineer. Wavetek maintains a factory-repair department for those customers not possessing the necessary personnel or test equipment to maintain the instrument. If an instrument is returned to the factory for calibration or repair, a detailed description of the specific problem should be attached to facilitate the turnaround time. The main board test point and adjustment locations are shown on the board itself, and all points are illustrated in the data package.

4.2 ACCESS INSTRUCTION

Removal of the top dust cover affords quick access to all the components within the unit. However, it may be necessary to remove the bottom dust cover to replace the components.

An extender board (located in the front left corner) is provided to allow testing and repair of individual boards while still in the circuit. To remove the extender board, remove the two screws located on the side panel.

4.2.1 Removing the Dust Cover

1. Unplug the power cord.
2. Unscrew two captive screws on top cover.
3. Remove top cover.
4. Follow same procedure for bottom cover removal.

4.3 RECOMMENDED TEST EQUIPMENT

Table 4-1 contains a list of recommended test equipment. Any test equipment having equivalent accuracies may be substituted for those listed.

Table 4-1. TEST EQUIPMENT

Type	Required Characteristics	Recommended Manufacturer	Model
Oscilloscope	To 250 MHz	Tektronix	454
Oscilloscope	To 30 MHz	Tektronix	544
Plug-In	Dual Channel	Tektronix	1A1
Plug-In	Peak mV measuring capability	Tektronix	1A5
Distortion Analyzer	To 600 kHz	Hewlett-Packard	334A
Spectrum Analyzer Display	To 50 MHz	Hewlett-Packard	141S
IF Section		Hewlett-Packard	8552A
RF Section		Hewlett-Packard	8553L
Differential Voltmeter	Microvolt dc measurement		
Counter-Timer	To 10 MHz 0.1% of reading accuracy		

4.4 CALIBRATION INSTRUCTIONS

The following paragraphs provide complete sequential calibration procedures for the Model 154 generator.

NOTE

The entire calibration procedure must be read first to determine initial control settings and test equipment connections required before attempting recalibration. The steps of this procedure should be performed in the sequence given, and the parts within each step should also be performed in the same sequence given. **Fold out page 4-21 for Adjustment and Test Point Locations.**

NOTE

Unless otherwise noted, all measurements made at the 50Ω OUT connector should be terminated into a 50Ω load when in ∿ , ∿ , or ⊓ modes and unterminated when in DC.

4.4.1 Preliminary Procedures

Allow the unit to warm up for at least 30 minutes. Start the calibration by setting the front panel switches and controls as follows:

POWER Switch . . . . . ON (IN)
FUNCTION Switch . . . . . ∿
All other push button switches should be in the OFF (OUT) position.
FREQUENCY . . . . . 9.99 X 100
DC/OFFSET 0 0.00
AMPLITUDE . . . . . 5.00 X 1.0

4.4.2 Power Supply Regulation

1. Connect a voltmeter to R5 (marked "+15 V" in ∿ AMPL section of the main board), and ground at TP1 (C15).
2. Adjust voltage to +15 Vdc ±20 mV, using R21 on the 15 V power supply board.
3. Check for approximately −15 volts at R7 (marked "−15 V" in ∿ AMPL section of the main board).
4. Check for approximately +24 volts at R4 and −24 volts at R3 in ∿ AMPL section of the main board. Test points are marked "+24 V" and "−24 V".
5. Connect a voltmeter to +23 volts across C72 (OUTPUT AMPL section of main board). Adjust voltage to +23 Vdc ±20 mV using R21 on the 23 V power supply board.
6. Check voltage across C70 for −23 Vdc ±400 mV.
7. Check the +6 volt supply in AUX AMPL section of main board and ground at TP1 (C15). Voltage should be +6 Vdc ±200 mV.

4.4.3 Triangle Amplitude Adjustment

1. Use a type W or 1A5 plug-in module with the scope for this calibration. Connect the oscilloscope probe (X1) to output of the triangle amplifier at TP2 and ground at TP1 on the main board. Make sure the frequency setting is at 9.99 X 100 Hz.
2. Adjust the positive peak of the triangle to +1.25 V ±5 mV using R21 on the main board.
3. Adjust the negative peak of the triangle to −1.25 V ±5 mV using R11 on the main board.

4.4.4 Frequency Calibration

1. Set function to ⊓ and connect the main output to the scope.
2. Set frequency to 0.09 X 0.1M. Alternately short and open VCG IN to ground and adjust R34 on the D/A amplifier board until no frequency shifting can be observed on the scope.
3. Connect the main output to a counter and verify that the shifting is less than 100 Hz.
4. Set frequency to 0.01 X 10K. Adjust R29 on the D/A amplifier board for 100 Hz ±15 Hz. (VCG should not be shorted to ground.)
5. Connect the output to an oscilloscope. Adjust the time symmetry to within 1% using R7 on the VCG board. A dual channel counter set in the B−A mode may also be used for this calibration. By alternately changing the slopes from positive to negative on both channels, the asymmetry may be measured.
6. Set frequency to 9.99 X 10 kHz. Adjust output frequency to 99.9 kHz ±100 Hz using R40 on D/A amplifier board.
7. Set frequency to 8.99 X 1 MHz. Adjust frequency to 8.99 MHz ±25 kHz using C4 on main board. Trim C2 if necessary.
8. Set frequency to 9.99 X 10K. Re-adjust frequency to 99.9 kHz ±100 Hz using R40 on D/A amplifier board. Trim R31 on D/A amplifier board if necessary.
9. Set frequency to 0.01 X 10 kHz. Re-adjust output frequency to 100 Hz ±15 Hz using R29 on D/A amplifier board.
10. Check frequency accuracy from 0.99 X 1M to 9.99 X 1M. All frequencies should be within ±1.8% of full scale. If not, re-adjust C4. If adjusting C4 does not help, try to trim capacitors C16, C17, C22 and C23 on the main board. Add 5 to 10 pF capacitance at locations C16 and C23, if frequency at the 9.99 X 1 MHz setting is too low. Reduce 5 to 10 pF of capacitance at both C17 and C22, if frequency at the 9.99 X 1 MHz setting is too high.

11. Set frequency to 9.99 X 0.1M. Adjust frequency to 999 kHz ±1 kHz using C6 on the main board. Trim C8 if necessary.

12. Set frequency to 9.99 X 1K. Adjust output frequency to 9.99 kHz ±10 Hz using R39 on D/A amplifier board.

13. Set frequency to 9.99 X 100. Adjust output frequency to 999 Hz ±1 Hz (or period to 1001 μs ±1 μs) using R38 on the D/A amplifier board.

14. Set frequency to 9.99 X 10. Adjust output frequency to 99.9 Hz ±0.1 Hz (or period to 10.01 ms ±10 μs) using R37 on the D/A amplifier board.

15. Connect a scope probe to the output of the triangle amplifier at TP2 and ground at TP1 on the main board.

16. Set generator to TRIG mode with front panel switch. Set frequency to 9.99 X 10 Hz. Adjust the dc level to 0 Vdc ±3 mV using R2 on the main board.

17. Set generator back to continuous running, frequency to 0.50 X 1.0 Hz, and function to ⊓⊔ . Adjust the time symmetry at the 50Ω OUT connector to less than 0.2% using R47 on the VCG board. In addition to using sweep magnifier on scope for this calibration, a dual channel counter may be used as described in Step 5 of Section 4.4.4.

18. Set frequency to 9.99 X 1.0 Hz. Adjust output frequency to 9.99 Hz ±0.01 Hz (or period to 100.1 ms ±0.1 ms) using R15 on the VCG board.

4.4.5 X-Y Multiplier Adjustment

1. Set function to DC, frequency to 2.00 X 100 Hz, and DC/OFFSET to 0 0.00.

2. Make sure the 50Ω output ground is not shorted to program ground by measuring the voltage between the two grounds; i.e., the grounds of 50Ω OUT and TRIG IN.

3. Connect the 50Ω OUT to an oscilloscope. Alternately short and open the 50Ω ground to the TRIG IN ground. Adjust R153 on the main board at the same time until the dc level at the output changes less than 5 mV.

NOTE

In case the voltage across the two grounds is too small and the effect is not obvious, an external voltage less than 10 Vdc can be applied momentarily between the two grounds for the above calibration. R153 should be adjusted for a dc shift of less than 5 mV.

4. Adjust R117 on the main board so that the output dc level stays within 10 mV at the 0.00 and 9.00 settings of the P-P AMPLITUDE VOLTS control.

5. Set DC/OFFSET to 0 Vdc ±20 mV using R132 on the main board.

6. Set function to ∿ (frequency remains at 2.00 X 100 Hz) and P-P AMPLITUDE to 0.00.

7. Adjust the voltage between TP3 and TP1 (GND) on main board to 0 Vdc ±5 mV using R8 on the D/A amplifier board. TP3 is located at one end of R110 in the X-Y multiplier section on the main board.

8. Adjust the 50Ω OUT signal to minimum using R118 on the main board.

9. Set P-P AMPLITUDE to 0.05 V. Adjust R124 on main board for the most linear waveform.

10. Reset P-P AMPLITUDE to 0.00. Repeat Step 8.

11. Set function to DC with P-P AMPLITUDE and DC/OFFSET still at 0.00. Adjust dc voltage at 50Ω OUT to 0 Vdc ±20 mV into open circuit using R132 on the main board.

12. Set function to ∿ and P-P AMPLITUDE to 0.00. Repeat Step 8.

4.4.6 Sine Distortion Adjustment

1. Set function to ∿ , frequency to 9.99 X 100 Hz, and P-P AMPLITUDE to 9.99.

2. Connect a scope probe (X1) to the output of the sine amplifier at TP4 and ground at TP1. Connect the other end to a low frequency sine distortion analyzer.

3. Adjust sine distortion for minimum using R85, R86 and R88 on the main board. These pots interact so several adjustments of each pot may be necessary for minimum distortion.

4. Adjust for minimum sine distortion at 50Ω OUT using R120 on the main board.

5. Check sine distortion at 9.99 X 1 kHz. Re-adjust R85, R86 and R88, if necessary, to obtain optimum sine distortion at 999 Hz and 9.99 kHz.

6. Set function to DC, frequency to 2.00 X 100 Hz and DC/OFFSET to 0 0.00. Repeat Steps 4 and 11 in Section 4.4.5 (X-Y Multiplier Adjustment).

4.4.7 Output Amplitude and DC Offset Adjustment

1. Set function to DC and P-P AMPLITUDE to 0.00. Adjust R18 on the D/A amplifier board so that the dc level at the 50Ω OUT connector changes less than 10 mV at different dc polarity settings: "–", "0" and "+".

2. Set P-P AMPLITUDE to 9.99 V, function to ∿, and frequency to 9.99 X 100 Hz.

3. Adjust output amplitude to 9.99 V p-p ±10 mV into a precision 50Ω load using R10 on the D/A amplifier board.

4. Set function to ∿. Adjust the amplitude to 9.99 V p-p ±10 mV using R108 on the main board.

5. Adjust the dc offset of ∿ output to less than ±10 mV using R93 on the main board.

6. Set function to ⊓⊔. Adjust the peak voltage to ±4.995 V ±5 mV using R57 and R54 on the main board for positive and negative peaks, respectively.

NOTE

If calibration cannot be achieved, trim R44 (on main board) so that the ⊓⊔ signal at the emitter of Q13 is symmetrical about ground within 200 mV.

7. Set function to DC and DC/OFFSET VOLTS to +9.99. Adjust the output voltage at 50Ω OUT connector to +9.99 V ±10 mV using R22 on the D/A amplifier board without a load.

8. Switch DC/OFFSET VOLTS to –9.99. The output voltage should be –9.99 V ±60 mV. If not, re-adjust R22 to obtain optimum calibration.

9. Set function to ∿, P-P AMPLITUDE to 0.00 and DC/OFFSET VOLTS to +4.99.

10. Adjust the dc offset at the 50Ω OUT connector to +4.99 V ±5 mV into a precision 50Ω load using R24 on the D/A amplifier board.

11. Switch the DC/OFFSET VOLTS to –4.99. The output voltage should be –4.99 V ±30 mV. If not, re-adjust R24 to obtain optimum calibration.

4.4.8 High Frequency Amplitude Response Adjustment

1. Set frequency to 1.00 X 1 MHz, DC/OFFSET to 0 0.00, P-P AMPLITUDE to 9.99 V, and function to ⊓⊔. Make sure that the output is loaded with a precision 50Ω load.

2. Adjust C75 and C77 on the main board for best looking square waveform.

3. Set function to ∿. Adjust for best amplitude flatness to 10 MHz with 1 kHz as reference using C49 on the main board.

4.4.9 Trigger Baseline Adjustment

1. Set function to ∿, frequency to 9.99 X 100 Hz, DC/OFFSET to 0 0.00, and P-P AMPLITUDE to 9.99 V. Generator should be in TRIG mode. Adjust output voltage to 0 Vdc ±10 mV using R2 on the main board.

2. Change frequency to 0.01 X 100 Hz. Adjust output voltage to 0 Vdc ±30 mV using R34 on the VCG board.

3. Change function to ∿. Adjust output voltage to 0 Vdc ±10 mV using R93 on the main board.

4.5 CORRECTIVE MAINTENANCE

This portion of the manual presents a systematic approach to trouble-shooting. It is composed of two parts. Part one (see 4.5.1) is a quick guide for locating the area of the problem. Part two (see 4.5.2) contains 12 tables which are given as detailed supplements to part one.

The following abbreviations are used:

Symbol	Meaning
B	Base (transistor)
C	Collector (transistor)
E	Emitter (transistor)
G	Gate (FET)
S	Source (FET)
D	Drain (FET)
CR	Diode
Qn	Transistor number (n)
V_{GS}	Voltage between gate and source (FET)
Q	Output terminal (flip-flop)
$\bar{Q}$	Inverting output terminal (flip-flop)

4.5.1 Quick Trouble-Shooting Guide

Symptom	Corrective Action
Blown Line Fuse	Replace fuse. If it blows again, check the following: 1. Solder bridge or wire connection shorted. 2. Q45 and/or Q46 shorted in output amplifier. 3. One of the 7 transistors mounted on the rear panel is shorted to itself or to another transistor through the chassis. 4. Follow Table 4-2 to locate the short in a particular supply. 5. By-pass capacitors for power supply are shorted. 6. Relay in −24 V supply is shorted.
+15 V Power Supply Malfunctions	1. Voltage low: a. Transformer output low. b. Extra current loading. Check for overheated and defective component in the circuit. c. Q2 or Q3 is shorted. d. Q1 is open. e. CR2 is shorted. f. IC1 is defective. 2. Voltage high: a. Power transistor TIP29 or Q1 is shorted. b. Q3 is open. c. IC1 is defective. 3. High frequency oscillation (MHz): a. C4 or C5 at IC1 is defective. b. One of the semiconductors in another part of the circuit is oscillating. Locate by using hand to touch the most sensitive area of the circuit boards. 4. Large 60 cycle noise: a. Dirty contact. Unplug the power board and clean the contact. b. Defective filter capacitor, C1 or C9.
Other Power Supply Malfunctions	1. Follow Table 4-2 to locate the problem to a particular power supply. 2. Use similar procedure for trouble-shooting as in the +15 V power supply malfunctions.
No Output Signals	1. If no ∿ signal is present at output of ∿ AMPL, follow Table 4-3 for trouble-shooting. 2. If no signal is present at pin 4 of IC2 in the X-Y multiplier on main board, follow Table 4-7 to check out relay logic. 3. If no signal is present at both emitters of Q31 and Q32 with the ∿ function selected, follow Table 4-12 to check out the X-Y multiplier. 4. If signal is seen at emitter of Q31 and Q32, follow Table 4-5 to check out the output amplifier.
No ∿ , ⊓ or SYNC Output	Follow Table 4-12 to check out the corresponding circuit.
⊓ Rise/Fall Time Abnormally Slow	1. Malfunctioning ⊓ amplifier. 2. One of the capacitors in the output amplifier is open. 3. C75 and C77 (output amplifier) are not calibrated. 4. C50, C53 or C52 in X-Y multiplier is open.

Quick Trouble-Shooting Guide (continued)

Symptom	Corrective Action
Frequency Accuracy Out of Specification	1. Check frequency calibration. 2. Check for defective C10, C16 to C23, CR18 and/or CR20 on main board, if problem is in X10K to X1 MHz ranges. 3. Check capacitance multiplier, if problem appears in X0.001 to X1 ranges only, using Table 4-6. 4. Check digit switch, D/A converter of frequency section, if problem appears to be in frequency setting, using Table 4-9. 5. Check VCG and D/A amplifier for frequency linearity problem in all ranges, using Table 4-4. 6. Follow Table 4-10 for frequency ranging problem.
High Frequency Output Has Abnormal Ringing	1. C69 on output amplifier is open. 2. Defective capacitor in output amplifier.
High Sine Distortion at Low Frequency	1. ∿ amplitude and time symmetry calibration is off. 2. Defective sine converter. 3. Sine converter or X-Y multiplier calibration is off. 4. Dirty contact on power supply board.
High Sine Distortion at High Frequency	1. ⊓ also looks bad, if problem is in the output amplifier. 2. Defective capacitors C10 and C16 to C23 in ∿ amplifier. 3. Defective C29 to C36 in sine amplifier. 4. Defective sine converter.
Unsymmetrical ∿	Follow Table 4-4 to check out the VCG circuit.
Amplitude Accuracy Out of Specification	1. Check calibration. 2. Check for defective C25, C31 and C67 for frequency linearity problem over 1 kHz. 3. Check digit switch and D/A converter for amplitude setting problem, using Table 4-9. 4. Follow Table 4-8 for amplitude ranging problem. 5. Check X-Y multiplier, using Table 4-12.
DC Offset Accuracy Out of Specification	1. Check calibration. 2. Check digit switch and D/A converter for offset setting problem, using Table 4-9. 3. Check for zero offset of X-Y multiplier and output amplifier.
TRIG and GATED Mode Inoperative	1. Check trigger and gated control switches. 2. Check for correct signals in the trigger circuit, using Table 4-11.

4.5.2 Trouble-Shooting Guide Tables

4.5.2.1 POWER SUPPLIES

Use Table 4-2 to localize the problem to a particular power supply and associated loading circuitry. In some cases, it is necessary to turn on the power of the unit no more than one or two seconds at a time to prevent it from blowing fuses and further damage circuit components.

NOTE

Be sure to use the correct ground in the following voltage checks.

Table 4-2. POWER SUPPLIES

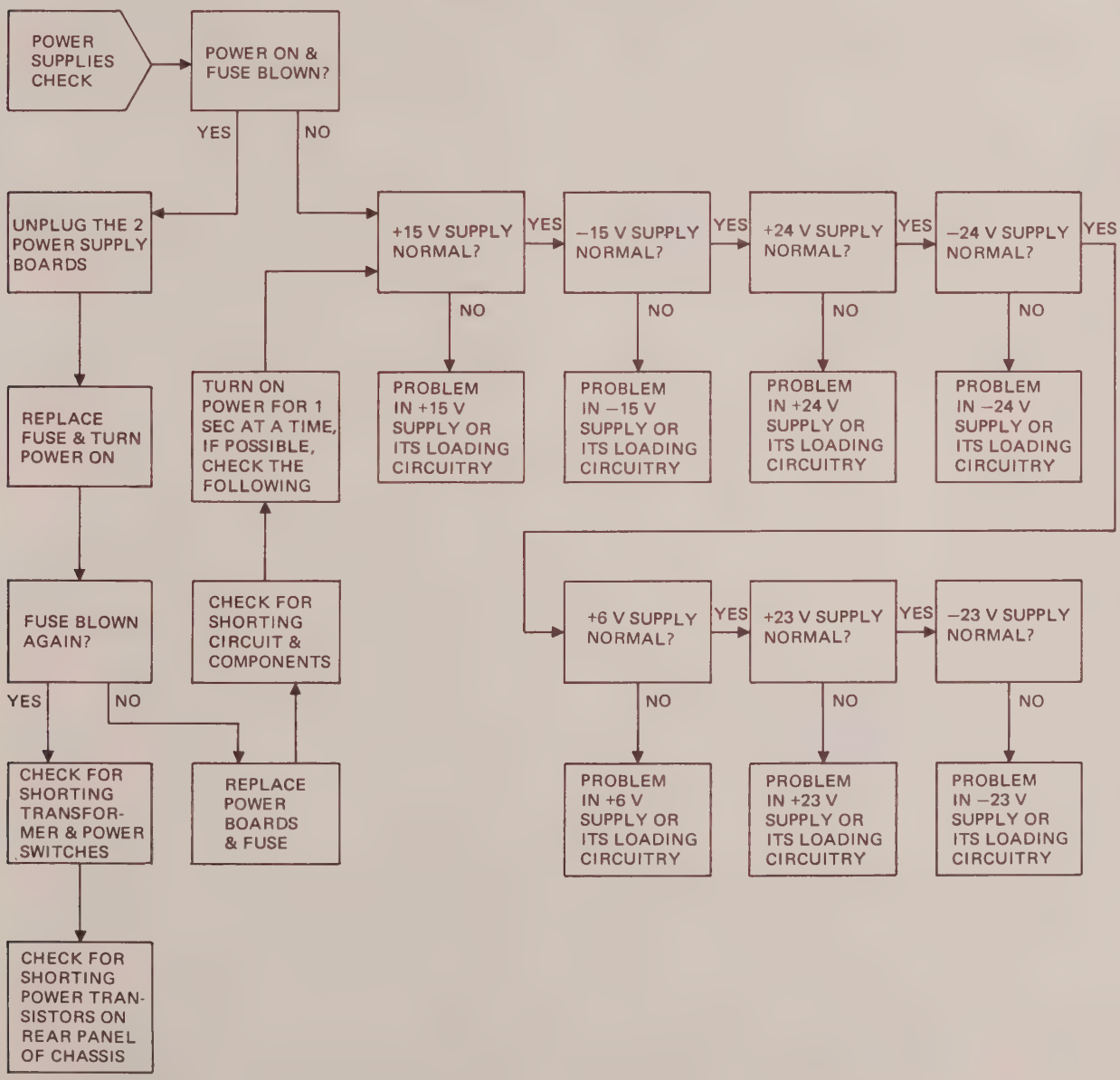

POWER SUPPLIES CHECK
POWER ON & FUSE BLOWN?
YES
NO
UNPLUG THE 2 POWER SUPPLY BOARDS
REPLACE FUSE & TURN POWER ON
FUSE BLOWN AGAIN?
YES
NO
CHECK FOR SHORTING TRANSFORMER & POWER SWITCHES
CHECK FOR SHORTING POWER TRANSISTORS ON REAR PANEL OF CHASSIS
REPLACE POWER BOARDS & FUSE
TURN ON POWER FOR 1 SEC AT A TIME, IF POSSIBLE, CHECK THE FOLLOWING
CHECK FOR SHORTING CIRCUIT & COMPONENTS
+15 V SUPPLY NORMAL?
YES
NO
PROBLEM IN +15 V SUPPLY OR ITS LOADING CIRCUITRY
−15 V SUPPLY NORMAL?
YES
NO
PROBLEM IN −15 V SUPPLY OR ITS LOADING CIRCUITRY
+24 V SUPPLY NORMAL?
YES
NO
PROBLEM IN +24 V SUPPLY OR ITS LOADING CIRCUITRY
−24 V SUPPLY NORMAL?
YES
NO
PROBLEM IN −24 V SUPPLY OR ITS LOADING CIRCUITRY
+6 V SUPPLY NORMAL?
YES
NO
PROBLEM IN +6 V SUPPLY OR ITS LOADING CIRCUITRY
+23 V SUPPLY NORMAL?
YES
NO
PROBLEM IN +23 V SUPPLY OR ITS LOADING CIRCUITRY
−23 V SUPPLY NORMAL?
NO
PROBLEM IN −23 V SUPPLY OR ITS LOADING CIRCUITRY

Table 4-3. TRIANGLE AMPLIFIER, COMPARATOR, AND HYSTERESIS SWITCH

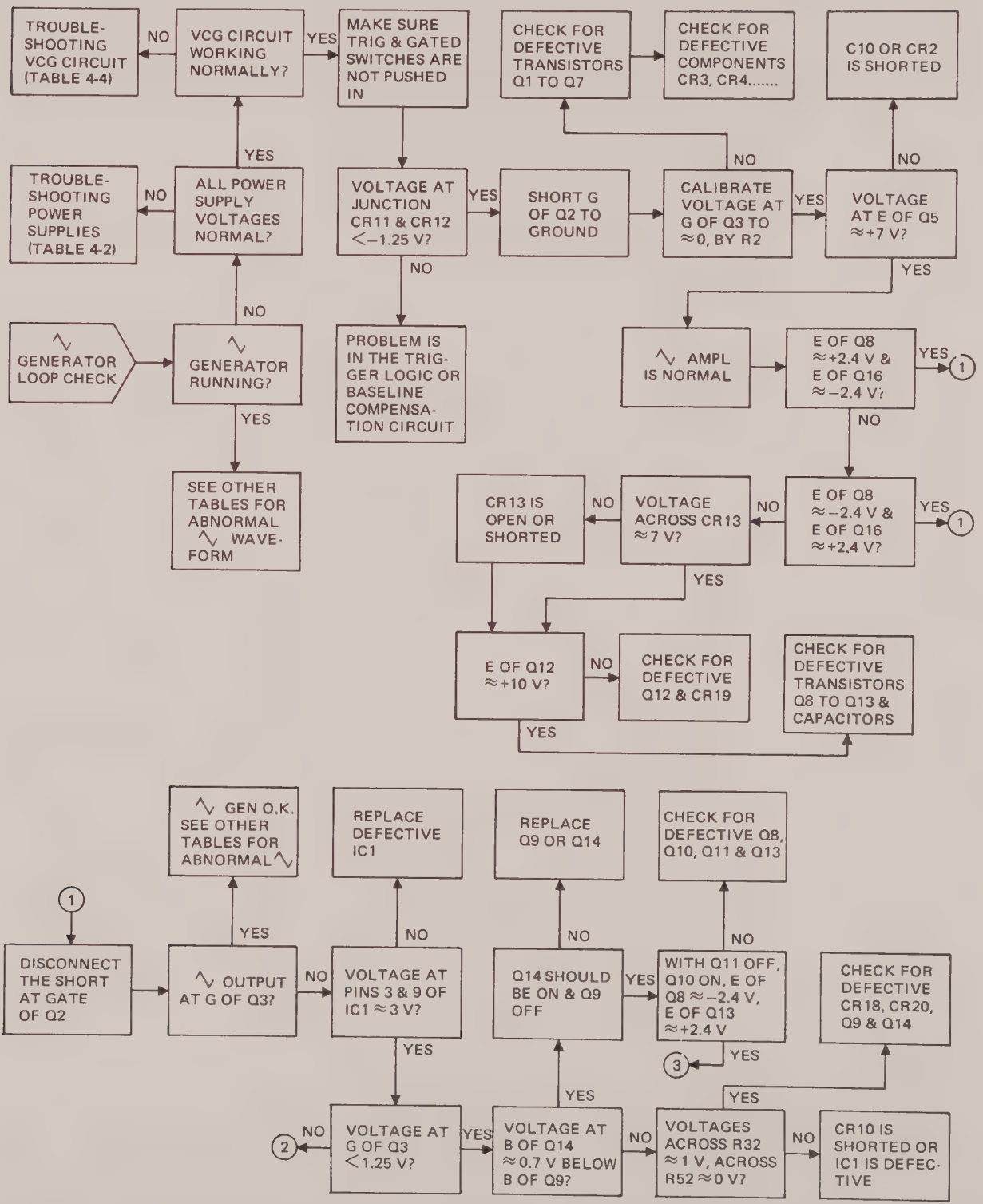

TROUBLE-SHOOTING VCG CIRCUIT (TABLE 4-4)
NO
VCG CIRCUIT WORKING NORMALLY?
YES
MAKE SURE TRIG & GATED SWITCHES ARE NOT PUSHED IN
CHECK FOR DEFECTIVE TRANSISTORS Q1 TO Q7
CHECK FOR DEFECTIVE COMPONENTS CR3, CR4.....
C10 OR CR2 IS SHORTED
YES
NO
NO
TROUBLE-SHOOTING POWER SUPPLIES (TABLE 4-2)
NO
ALL POWER SUPPLY VOLTAGES NORMAL?
VOLTAGE AT JUNCTION CR11 & CR12 <−1.25 V?
YES
SHORT G OF Q2 TO GROUND
CALIBRATE VOLTAGE AT G OF Q3 TO ≈0, BY R2
YES
VOLTAGE AT E OF Q5 ≈+7 V?
NO
YES
NO
GENERATOR LOOP CHECK
GENERATOR RUNNING?
PROBLEM IS IN THE TRIG-GER LOGIC OR BASELINE COMPENSA-TION CIRCUIT
AMPL IS NORMAL
E OF Q8 ≈+2.4 V & E OF Q16 ≈−2.4 V?
YES
1
NO
YES
SEE OTHER TABLES FOR ABNORMAL WAVE-FORM
CR13 IS OPEN OR SHORTED
NO
VOLTAGE ACROSS CR13 ≈7 V?
NO
E OF Q8 ≈−2.4 V & E OF Q16 ≈+2.4 V?
YES
1
YES
E OF Q12 ≈+10 V?
NO
CHECK FOR DEFECTIVE Q12 & CR19
CHECK FOR DEFECTIVE TRANSISTORS Q8 TO Q13 & CAPACITORS
YES
GEN O.K. SEE OTHER TABLES FOR ABNORMAL
REPLACE DEFECTIVE IC1
REPLACE Q9 OR Q14
CHECK FOR DEFECTIVE Q8, Q10, Q11 & Q13
1
DISCONNECT THE SHORT AT GATE OF Q2
YES
OUTPUT AT G OF Q3?
NO
VOLTAGE AT PINS 3 & 9 OF IC1 ≈3 V?
NO
Q14 SHOULD BE ON & Q9 OFF
YES
WITH Q11 OFF, Q10 ON, E OF Q8 ≈−2.4 V, E OF Q13 ≈+2.4 V
NO
CHECK FOR DEFECTIVE CR18, CR20, Q9 & Q14
YES
3
YES
YES
2
NO
VOLTAGE AT G OF Q3 <1.25 V?
YES
VOLTAGE AT B OF Q14 ≈0.7 V BELOW B OF Q9?
NO
VOLTAGES ACROSS R32 ≈1 V, ACROSS R52 ≈0 V?
NO
CR10 IS SHORTED OR IC1 IS DEFEC-TIVE

Table 4-3. TRIANGLE AMPLIFIER, COMPARATOR, AND HYSTERESIS SWITCH (Continued)

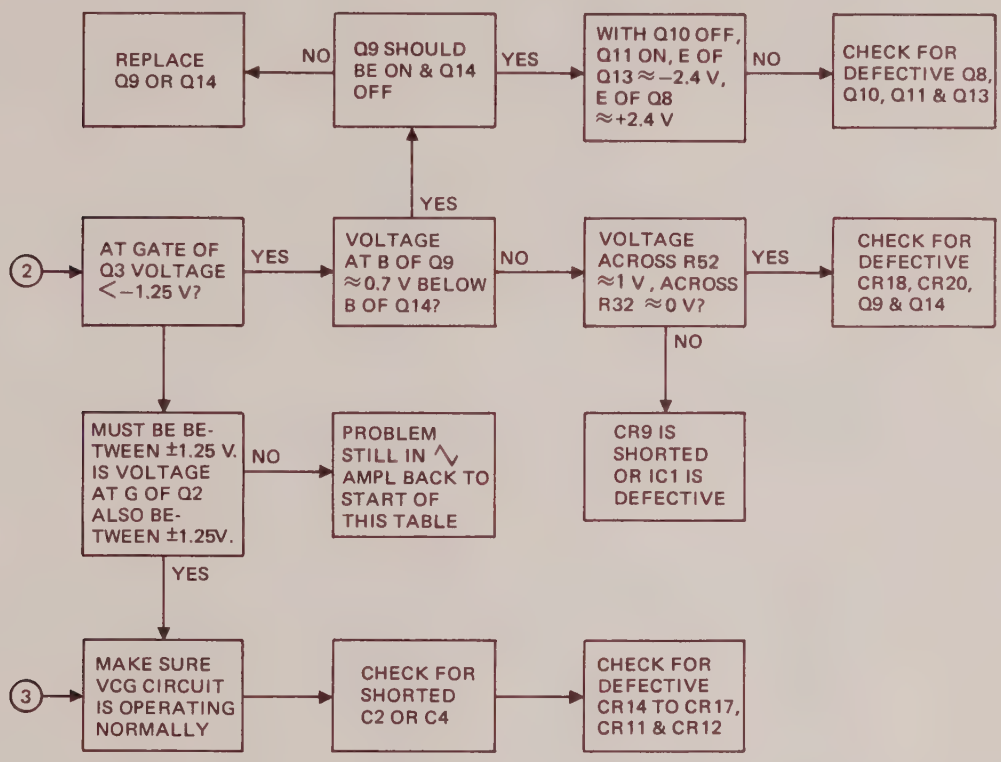

REPLACE Q9 OR Q14
NO
Q9 SHOULD BE ON & Q14 OFF
YES
WITH Q10 OFF, Q11 ON, E OF Q13 ≈ −2.4 V, E OF Q8 ≈ +2.4 V
NO
CHECK FOR DEFECTIVE Q8, Q10, Q11 & Q13
YES
2
AT GATE OF Q3 VOLTAGE < −1.25 V?
YES
VOLTAGE AT B OF Q9 ≈ 0.7 V BELOW B OF Q14?
NO
VOLTAGE ACROSS R52 ≈ 1 V, ACROSS R32 ≈ 0 V?
YES
CHECK FOR DEFECTIVE CR18, CR20, Q9 & Q14
NO
MUST BE BETWEEN ±1.25 V. IS VOLTAGE AT G OF Q2 ALSO BETWEEN ±1.25V.
NO
PROBLEM STILL IN ∿ AMPL BACK TO START OF THIS TABLE
CR9 IS SHORTED OR IC1 IS DEFECTIVE
YES
3
MAKE SURE VCG CIRCUIT IS OPERATING NORMALLY
CHECK FOR SHORTED C2 OR C4
CHECK FOR DEFECTIVE CR14 TO CR17, CR11 & CR12

Table 4-4. VCG AND CURRENT SOURCE

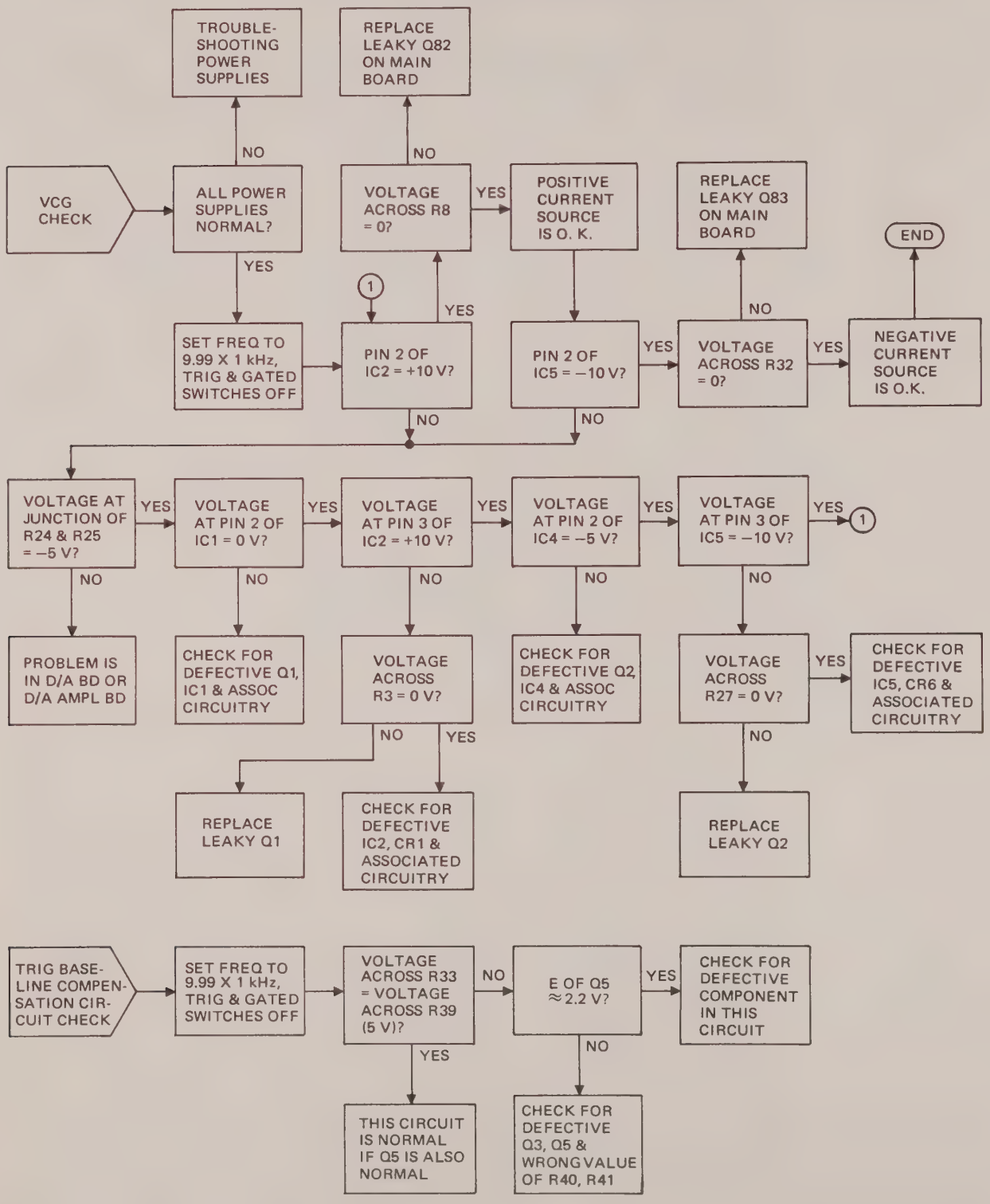

VCG CHECK
ALL POWER SUPPLIES NORMAL?
NO
TROUBLE-SHOOTING POWER SUPPLIES
YES
SET FREQ TO 9.99 X 1 kHz, TRIG & GATED SWITCHES OFF
PIN 2 OF IC2 = +10 V?
1
NO
YES
VOLTAGE ACROSS R8 = 0?
NO
REPLACE LEAKY Q82 ON MAIN BOARD
YES
POSITIVE CURRENT SOURCE IS O. K.
PIN 2 OF IC5 = −10 V?
NO
YES
VOLTAGE ACROSS R32 = 0?
NO
REPLACE LEAKY Q83 ON MAIN BOARD
YES
NEGATIVE CURRENT SOURCE IS O.K.
END
VOLTAGE AT JUNCTION OF R24 & R25 = −5 V?
NO
PROBLEM IS IN D/A BD OR D/A AMPL BD
YES
VOLTAGE AT PIN 2 OF IC1 = 0 V?
NO
CHECK FOR DEFECTIVE Q1, IC1 & ASSOC CIRCUITRY
YES
VOLTAGE AT PIN 3 OF IC2 = +10 V?
NO
VOLTAGE ACROSS R3 = 0 V?
NO
REPLACE LEAKY Q1
YES
CHECK FOR DEFECTIVE IC2, CR1 & ASSOCIATED CIRCUITRY
YES
VOLTAGE AT PIN 2 OF IC4 = −5 V?
NO
CHECK FOR DEFECTIVE Q2, IC4 & ASSOC CIRCUITRY
YES
VOLTAGE AT PIN 3 OF IC5 = −10 V?
NO
VOLTAGE ACROSS R27 = 0 V?
NO
REPLACE LEAKY Q2
YES
CHECK FOR DEFECTIVE IC5, CR6 & ASSOCIATED CIRCUITRY
YES
1
TRIG BASE-LINE COMPEN-SATION CIR-CUIT CHECK
SET FREQ TO 9.99 X 1 kHz, TRIG & GATED SWITCHES OFF
VOLTAGE ACROSS R33 = VOLTAGE ACROSS R39 (5 V)?
NO
E OF Q5 ≈2.2 V?
YES
CHECK FOR DEFECTIVE COMPONENT IN THIS CIRCUIT
NO
CHECK FOR DEFECTIVE Q3, Q5 & WRONG VALUE OF R40, R41
YES
THIS CIRCUIT IS NORMAL IF Q5 IS ALSO NORMAL

Table 4-5. OUTPUT AMPLIFIER

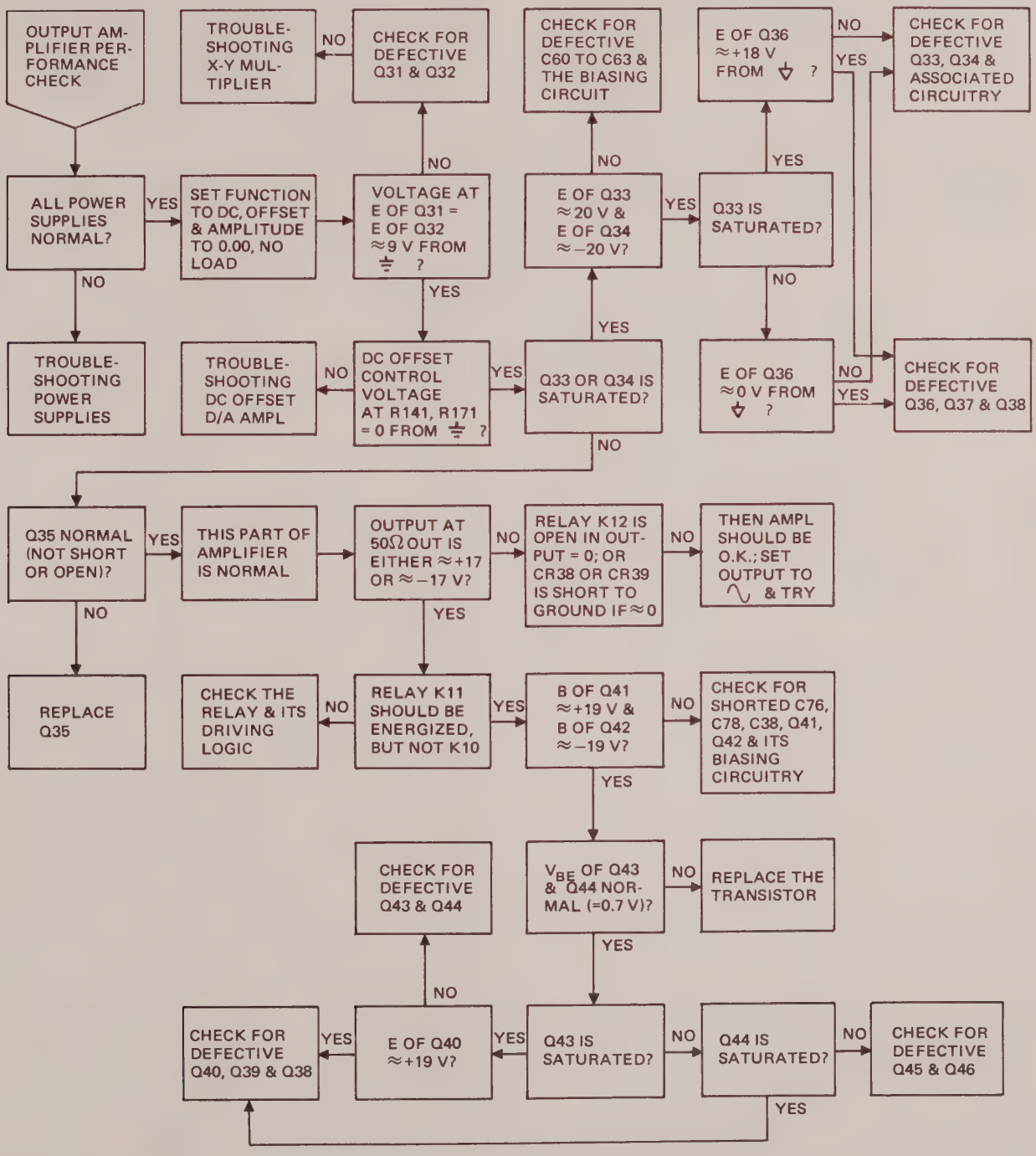

OUTPUT AMPLIFIER PERFORMANCE CHECK
ALL POWER SUPPLIES NORMAL?
YES
NO
TROUBLESHOOTING POWER SUPPLIES
SET FUNCTION TO DC, OFFSET & AMPLITUDE TO 0.00, NO LOAD
VOLTAGE AT E OF Q31 = E OF Q32 ≈9 V FROM ⏚ ?
NO
YES
TROUBLESHOOTING DC OFFSET D/A AMPL
DC OFFSET CONTROL VOLTAGE AT R141, R171 = 0 FROM ⏚ ?
NO
YES
TROUBLESHOOTING X-Y MULTIPLIER
CHECK FOR DEFECTIVE Q31 & Q32
NO
CHECK FOR DEFECTIVE C60 TO C63 & THE BIASING CIRCUIT
NO
E OF Q33 ≈20 V & E OF Q34 ≈−20 V?
YES
Q33 OR Q34 IS SATURATED?
YES
NO
E OF Q36 ≈+18 V FROM ⏚ ?
NO
YES
CHECK FOR DEFECTIVE Q33, Q34 & ASSOCIATED CIRCUITRY
Q33 IS SATURATED?
YES
NO
E OF Q36 ≈0 V FROM ⏚ ?
NO
YES
CHECK FOR DEFECTIVE Q36, Q37 & Q38
Q35 NORMAL (NOT SHORT OR OPEN)?
YES
NO
REPLACE Q35
THIS PART OF AMPLIFIER IS NORMAL
OUTPUT AT 50Ω OUT IS EITHER ≈+17 OR ≈−17 V?
NO
YES
RELAY K12 IS OPEN IN OUTPUT = 0; OR CR38 OR CR39 IS SHORT TO GROUND IF ≈0
NO
THEN AMPL SHOULD BE O.K.; SET OUTPUT TO ∿ & TRY
CHECK THE RELAY & ITS DRIVING LOGIC
NO
RELAY K11 SHOULD BE ENERGIZED, BUT NOT K10
YES
B OF Q41 ≈+19 V & B OF Q42 ≈−19 V?
NO
YES
CHECK FOR SHORTED C76, C78, C38, Q41, Q42 & ITS BIASING CIRCUITRY
CHECK FOR DEFECTIVE Q43 & Q44
NO
V_{BE} OF Q43 & Q44 NORMAL (=0.7 V)?
NO
YES
REPLACE THE TRANSISTOR
CHECK FOR DEFECTIVE Q40, Q39 & Q38
YES
E OF Q40 ≈+19 V?
YES
Q43 IS SATURATED?
NO
Q44 IS SATURATED?
NO
YES
CHECK FOR DEFECTIVE Q45 & Q46

Table 4-6. CAPACITANCE MULTIPLIER

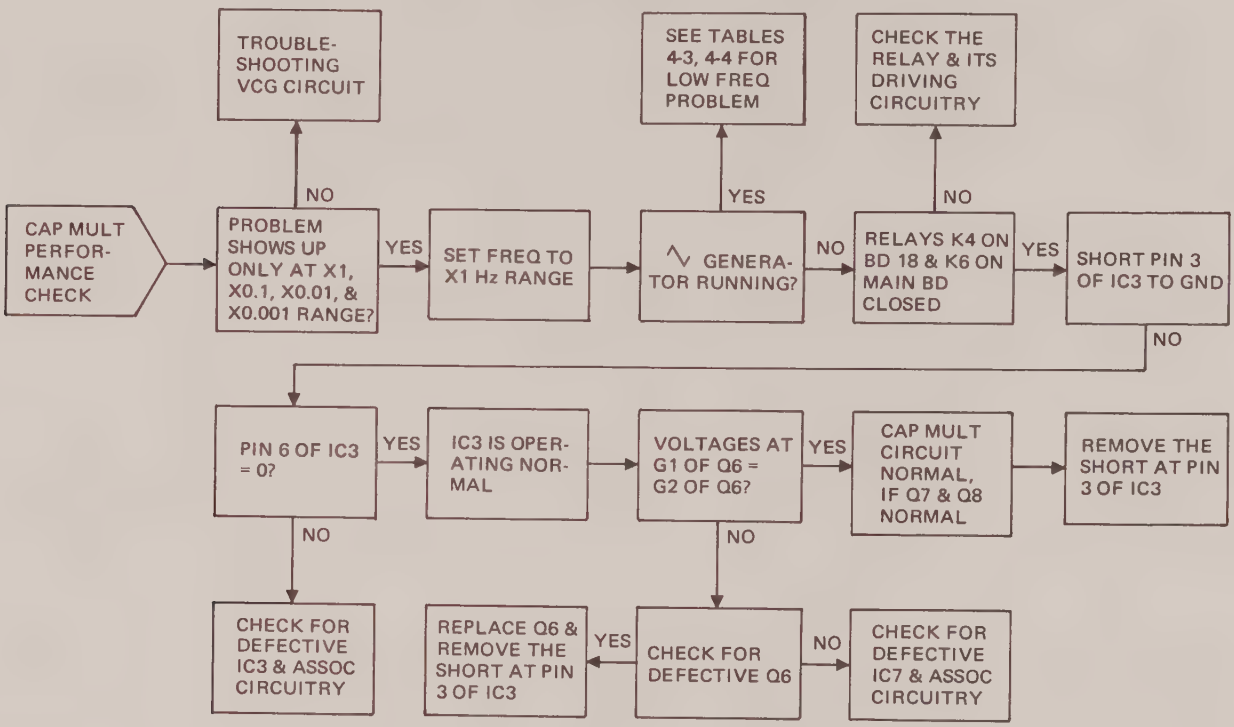

CAP MULT PERFOR-MANCE CHECK
PROBLEM SHOWS UP ONLY AT X1, X0.1, X0.01, & X0.001 RANGE?
NO
TROUBLE-SHOOTING VCG CIRCUIT
YES
SET FREQ TO X1 Hz RANGE
∿ GENERA-TOR RUNNING?
YES
SEE TABLES 4-3, 4-4 FOR LOW FREQ PROBLEM
NO
RELAYS K4 ON BD 18 & K6 ON MAIN BD CLOSED
NO
CHECK THE RELAY & ITS DRIVING CIRCUITRY
YES
SHORT PIN 3 OF IC3 TO GND
NO
PIN 6 OF IC3 = 0?
NO
CHECK FOR DEFECTIVE IC3 & ASSOC CIRCUITRY
YES
IC3 IS OPER-ATING NOR-MAL
VOLTAGES AT G1 OF Q6 = G2 OF Q6?
NO
CHECK FOR DEFECTIVE Q6
YES
REPLACE Q6 & REMOVE THE SHORT AT PIN 3 OF IC3
NO
CHECK FOR DEFECTIVE IC7 & ASSOC CIRCUITRY
YES
CAP MULT CIRCUIT NORMAL, IF Q7 & Q8 NORMAL
REMOVE THE SHORT AT PIN 3 OF IC3

Table 4-7. FUNCTION LOGIC

COMPONENTS / FUNCTION	Q58	Q59	Q60	Q61	Q62	Q63	Q64	K7	K8	K9
∿	X		X							
∿	X			X	X			X		
⎍		X		X		X			X	X
DC (Also see Table 4-8)		X	X				X			X

NOTES: 1. *For standard logic only. For inverse logic, interchange Q58 with Q59 and Q60 with Q61.*

2. *For TRIG and GATED logic, see Timing Diagram, Table 4-11.*

3. *The transistor or relay with "X" is in an "ON" state.*

4.5.2.2 AMPLITUDE RANGING CONTROL LOGIC

Table 4-8 is provided as a hint for trouble-shooting amplitude ranging control logic.

1. At X0.1 range, only Q48,Q49,Q51,Q56 and K13 are "ON" and all other transistors and relays should be "OFF".
2. Relay K12 should never be "ON" when K13, K14 or K15 is "ON".

Table 4-8. AMPLITUDE RANGING CONTROL LOGIC

COMPONENTS / AMPL RANGE	ALL COMPONENTS ARE ON MAIN CIRCUIT BOARD										
	STANDARD LOGIC ONLY, FOR INVERSE LOGIC, INTERCHANGE Q47 WITH Q48 AND Q49 WITH Q50				RELAY OR LOGIC DRIVER (ON)	(K1, D/A AMPL BOARD)					
	Q47	Q48	Q49	Q50		K10	K11	K12	K13	K14	K15
X1		X		X	Q54 Q55		X	X			
X0.1		X	X		Q51 Q56				X		
X0.01	X			X	Q52 Q56					X	
X0.001	X		X		Q53 Q56						X
DC output (Also see Table 4-7	Not Applicable		Not Applicable		Q57 Q55	X	X	X			

NOTE: The transistor or relay with "X" is in an "ON" state.

4.5.2.3 D/A CONVERTER

The D/A converter can easily be checked out by comparing the voltage level at the cathode of each switching diode according to Table 4-9. If the voltage level is not in agreement with the table, check for correct voltage at the connector and the associated circuitry.

Pin No. 1 at the connector is the summing node of the D/A amplifier and should be 0 Vdc. If not, the problem is in the D/A amplifier.

Table 4-9. D/A CONVERTER

COMPONENTS / FREQ AMPL OR OFFSET SETTINGS	PIN NUMBER AT CONNECTOR D/A CONVERTER BOARD												DIODE (CR) NUMBER (VOLTAGE AT CATHODE)											
	3	4	5	6	7	8	9	11	12	13	14	15	40	37	34	30	27	24	21	17	14	11	8	4
0.00	0	0	0	0	0	0	0	0	0	0	0	0	L	L	L	L	L	L	L	L	L	L	L	L
1.11	1	0	0	0	1	0	0	0	1	0	0	0	H	L	L	L	H	L	L	L	H	L	L	L
2.22	0	1	0	0	0	1	0	0	0	1	0	0	L	H	L	L	L	H	L	L	L	H	L	L
3.33	1	1	0	0	1	1	0	0	1	1	0	0	H	H	L	L	H	H	L	L	H	H	L	L
4.44	0	0	1	0	0	0	1	0	0	0	1	0	L	L	H	L	L	L	H	L	L	L	H	L
5.55	1	0	1	0	1	0	1	0	1	0	1	0	H	L	H	L	H	L	H	L	H	L	H	L
6.66	0	1	1	0	0	1	1	0	0	1	1	0	L	H	H	L	L	H	H	L	L	H	H	L
7.77	1	1	1	0	1	1	1	0	1	1	1	0	H	H	H	L	H	H	H	L	H	H	H	L
8.88	0	0	0	1	0	0	0	1	0	0	0	1	L	L	H	H	L	L	H	H	L	L	H	H
9.99	1	0	0	1	1	0	0	1	1	0	0	1	H	L	H	H	H	L	H	H	H	L	H	H

NOTE: H = +6 V.
L = 0 V.
1 is > 2.4 V for standard logic, < 1 V for inverting logic.
0 is < 1 V for standard logic, > 2.4 V for inverting logic.

4.5.2.4 FREQUENCY RANGING LOGIC

Table 4-10 is provided as a hint for trouble-shooting frequency ranging and calibration problems. A few typical examples are listed below to clarify the use of this table.

1. Defective Q16, C12, K3, R39 or K6 will cause abnormal frequency output at X1K range. Shorted C3 will have 0 Vdc output. Inoperative K4 will have frequency output as at X1 MHz range, etc.

2. Frequency stays the same at all ranges from X0.001 to X10 Hz, if relay K6 is not energized or is open.

3. Frequency out of specification at X10K, X0.1M and X1M ranges indicates that R40 is not properly calibrated.

4. Each pair of transistors, Q1 and Q2, Q3 and Q4, Q5 and Q6, and Q7 and Q8, should never be "ON" or "OFF" simultaneously. If this occurs, all frequency ranging is wrong, or there is no ranging control at all.

Table 4-10. FREQUENCY RANGING LOGIC

COMPONENTS / FREQ RANGING	TRANSISTORS ON FREQ RANGING BOARD (See Note 1)				MAIN BD										VCG BD				D/A AMPL BD			
					RELAY OR LOGIC DRIVER (ON)	C6 C7 C8	C11	C12	C13	C14 C15	CAP MULT				R18 R19	R20 R21	R22 R23	R16 R17	R37	R38	R39	R40
	Q1 Q2	Q3 Q4	Q5 Q6	Q7 Q8		K1	K2	K3	K4	K5	K6				K1	K2	K3	K4	K4	K5	K6	K7
X0.001	X	X	X	X	Q9, Q21 Q13, Q14					X	X				X				X			
X0.01	X	X	X	X	Q10, Q21 Q13, Q14					X	X					X			X			
X0.1	X	X	X	X	Q11, Q21 Q13, Q14					X	X						X		X			
X1	X	X	X	X	Q12, Q21 Q13, Q14					X	X							X	X			
X10	X	X	X	X	Q14					X									X			
X100	X	X	X	X	Q15				X											X		
X1K	X	X	X	X	Q16			X													X	
X10K	X	X	X	X	Q17, Q18 Q20		X															X
X0.1M	X	X	X	X	Q18, Q19 Q20	X																X
X1M	X	X	X	X	Q18, Q20																	X

NOTES: 1. For standard control logic only (for inverse logic, interchange each pair of transistors).
2. The transistor or relay with "X" is in its "ON" state.

4.5.2.5 TRIGGER AND GATED LOGIC TIMING

For trouble-shooting the trigger, set the generator at GATED mode. Refer to Table 4-11. Draw a vertical line on the timing diagram along t_1 or t_2, depending on whether the TRIG IN signal is low or high, and check for correct voltage levels according to the timing diagram.

After the GATED mode has been checked out and is working normally, the TRIG mode can be checked in the same way but concentrated in the Q78, Q77 area.

Table 4-11. TRIGGER AND GATED LOGIC TIMING DIAGRAM

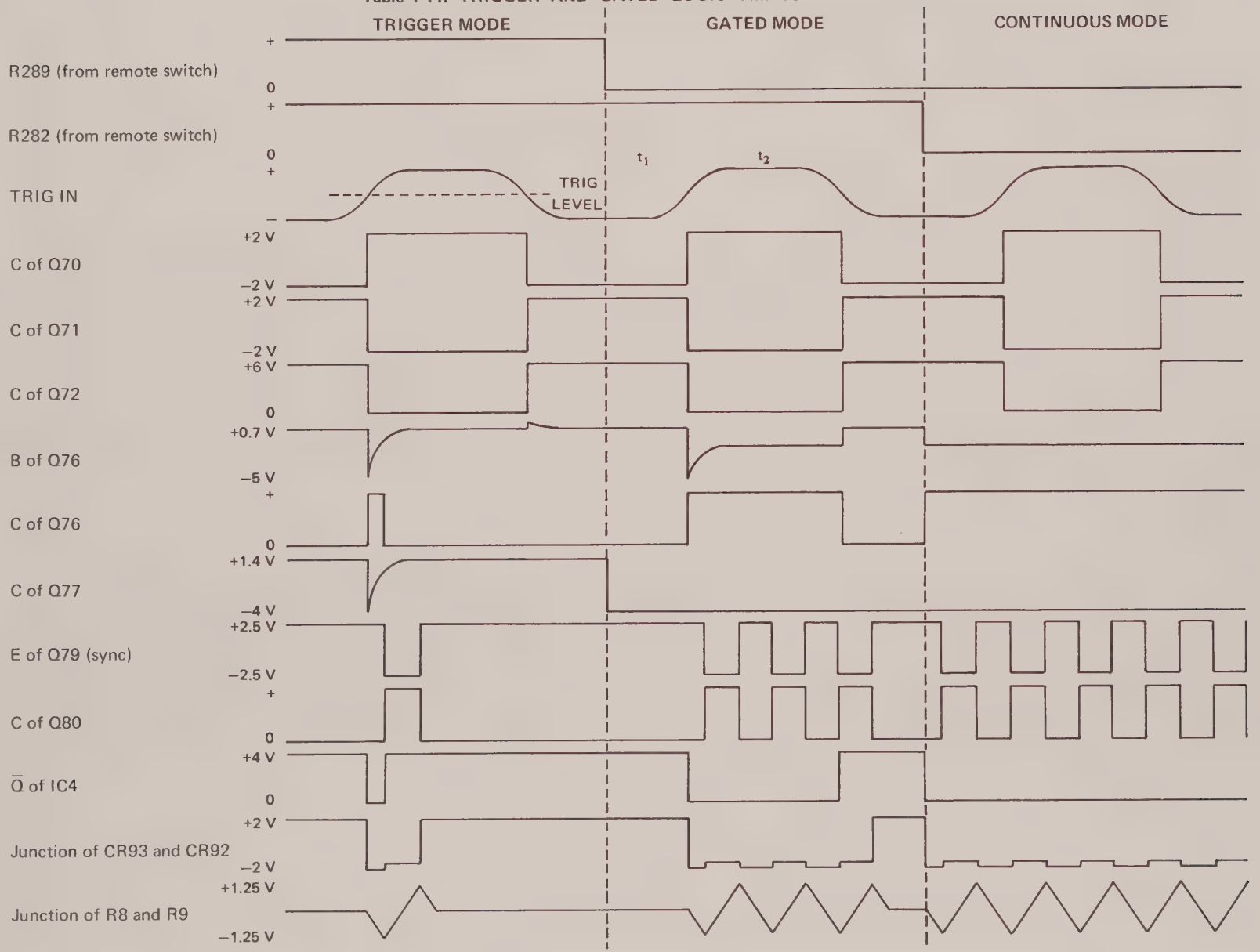


Table 4-12. KEY SIGNAL AND VOLTAGE

∿ AMPLIFIER, COMPARATOR AND HYSTERESIS SWITCH

Test Point	Typical Voltage
G of Q2	2.5 V p-p ∿ , 0 Vdc offset
G of Q3	2.5 V p-p ∿ , 0 Vdc offset
E of Q5	2.5 V p-p ∿ , ≈ +7 Vdc offset
Pins 1 and 4 of IC1	See Table 4-13
Pins 2 and 8	−3 V
Pins 3 and 9	−3.7 V
E of Q14	+6.8 Vdc
B of Q14 and Q9	See Table 4-13
E of Q8 and Q13	See Table 4-13
E of Q12	+10 V
R42 and R45 junction	−3 V
S of Q82	+10 V to +15 V, dependent on frequency setting
S of Q83	−10 V to −15 V, dependent on frequency setting

∿ CONVERTER AND AMPLIFIER

Test Point	Typical Voltage
Pin 2 of A1	See Table 4-13
Pin 4 of A1	+14 V
Pin 1 of A1	−14 V
Pin 5 of A1	250 mV p-p ∿ , 0 Vdc offset
R75 and R76 junction	2.5 V p-p ∿ , 0 Vdc offset
B of Q17 and Q18	+8 V

SYNC AND SQUARE AMPLIFIER

Test Point	Typical Voltage
R84 and R56 junction	±2.4 V ⊓
CR27 cathode	±1.25 V ⊓
R95 and R96 junction	±1.25 V ⊓

AUX AMPLIFIER

Test Point	Typical Voltage
E of Q26	0 to +6 V ⊓
E of Q27	+3.5 V
C of Q29	0 to +6 V ⊓ , < 5 ns RF time

X-Y MULTIPLIER

Test Point	Typical Voltage
R111	Selected signal (∿ , ∿ , ⊓ or DC)
R110	VCA input, voltage dependent on amplitude setting
Pins 8 and 12 of IC2	0 Vdc
Pin 5 of IC2	Same signal as at pin 4, but −1.4 V offset
Pins 6 and 11 of IC2	−1.4 V
Pin 10 of IC2	−1.4 V below pin 9
Pins 3 and 13	−13.5 V
Pin 1 of IC2	+5 V
E of Q32	Selected signal output, +9 Vdc offset, amplitude dependent on setting
E of Q31	Inverted output of Q32

OUTPUT AMPLIFIER

Test Point	Typical Voltage
Voltage between ⏚ and ▽	−1 to +1 V (when floating)
E of Q33	+19 Vdc
E of Q34	−19 Vdc
R157 and R158 junction	+0.7 Vdc
E of Q35	Selected waveform, 0 to 1 V p-p
E of Q36	+10 V ±5 V
B of Q41	+19 Vdc
E of Q43	+19 Vdc
B of Q42	−19 Vdc
E of Q44	−19 Vdc
R166 and R168 junction	+0.7 Vdc
E of Q37 and Q39	+19 Vdc
E of Q40	+2 V to +18 V
R192 and R193 junction	Main output, ±15 V maximum

D/A AMPLIFIER

Pins 2 and 3 of all D/A amplifiers (IC1, IC2 and IC3) are 0 Vdc. Their output voltages are dependent on front panel and remote control settings. The gain of IC2 will decrease to ½ when dc output is selected and K1 is closed.

Table 4-12. KEY SIGNAL AND VOLTAGE (Continued)

VCG AMPLIFIER AND TRIGGER BASELINE COMPENSATION

Test Point	Typical Voltage
R24 and R25 junction	0 to −5 V*
S of Q1	0 V
Pins 2 and 3 of IC2	+15 to +10 V*
S of Q2	0 to −5 V*
Pins 2 and 3 of IC5	−15 to −10 V*
V_{GS} of Q3	$V_{G1,S1} = V_{G2,S2}$
R36 and R37	Voltage across both are equal
E of Q5	+2.2 V
R36	Voltage across R39 and R29 are equal

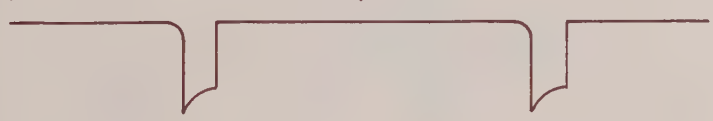
*Voltage is dependent on a frequency setting of 0.00 to 9.99.

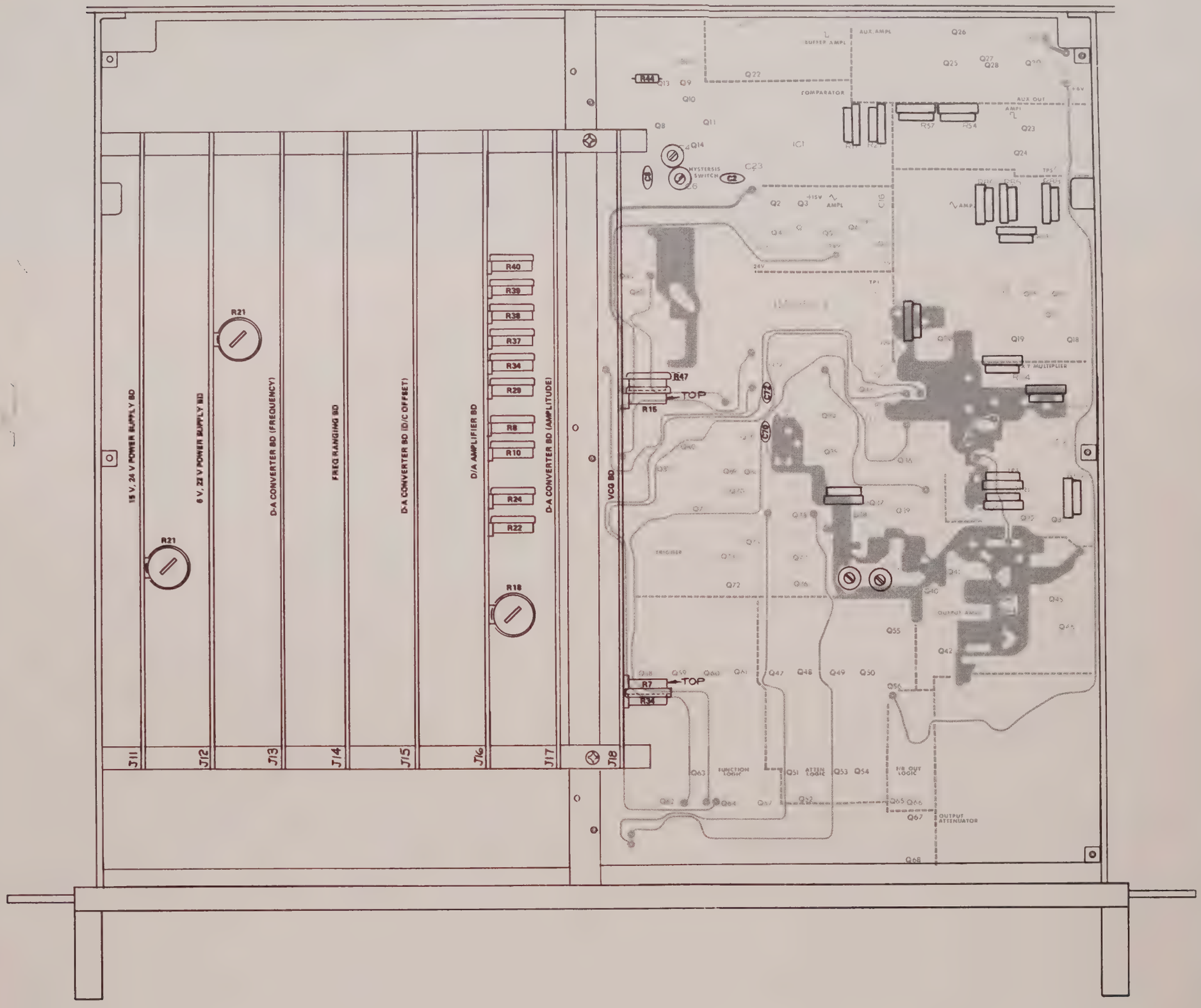
CAPACITANCE MULTIPLIER*

Test Point	Typical Voltage
G1 and G2 of Q6	±1.25 V ∿
Pin 6 of IC7	⊓⊔, amplitude dependent on frequency setting
Pins 2 and 3 of IC3	±1.25 V ∿
Pin 6 of IC3	±7.50 V ∿

*The above information applies if the frequency range is at X1 Hz.

Table 4-13. KEY WAVEFORMS

Test Point	Waveforms
AUX OUT	
G of Q2 G of Q3	+1.25 V −1.25 V
Pin 1 of IC1	+0.7 V −0.5 V
Pin 4 of IC1	+0.5 V −0.7 V
B of Q14	+7 V +6.3 V 
B of Q9	+7 V +6.3 V
E of Q8	+2.4 V −2.4 V
E of Q13	+2.4 V −2.4 V
CR16 Anode	+2 V −2 V
CR17 Cathode	+2 V −2 V
P2 of A1	+0.6 V −0.6 V
P5 of A1	+0.12 V −0.12 V
R75 and R76	+1.25 V −1.25 V



ADJUSTMENT AND TEST POINT LOCATIONS

SECTION 5
DIAGRAMS ADDENDUMS AND PARTS LISTS

5.1 DIAGRAMS

The schematic diagrams within this manual are, wherever possible, arranged in the sequence followed in the circuit description. Whenever assembly drawings are included, they are positioned adjacent to the schematics for maximum information presentation and minimum page flipping. Additional voltage or waveform information, beyond that given in the circuit description, may be shown on the schematic diagrams, at test points and key locations throughout the instrument.

5.2 ADDENDUMS

Under WAVETEK's product improvement program, the latest electronic designs and circuits are incorporated into each WAVETEK instrument as quickly as development and testing permit. Because of the time needed to compose and print instruction manuals, it is not always possible to include the most recent changes in the initial printing. Whenever this occurs, addendum pages are prepared to summarize the changes made under a WAVETEK Engineering Change Notice (ECN) and these ECN pages are inserted immediately inside the rear cover. If no such pages exist, the manual should be correct as printed.

5.3 PARTS LISTS

Whenever possible, an assembly drawing and the associated parts list are kept to one piece of paper or are positioned for maximum information presentation. When ordering spare parts, please specify part number, circuit reference, board, serial number of unit, and if applicable, the function performed.

DRAWINGS

The following assembly drawings (with parts lists) and schematics will be included at the rear of this manual, in the arrangement shown below:

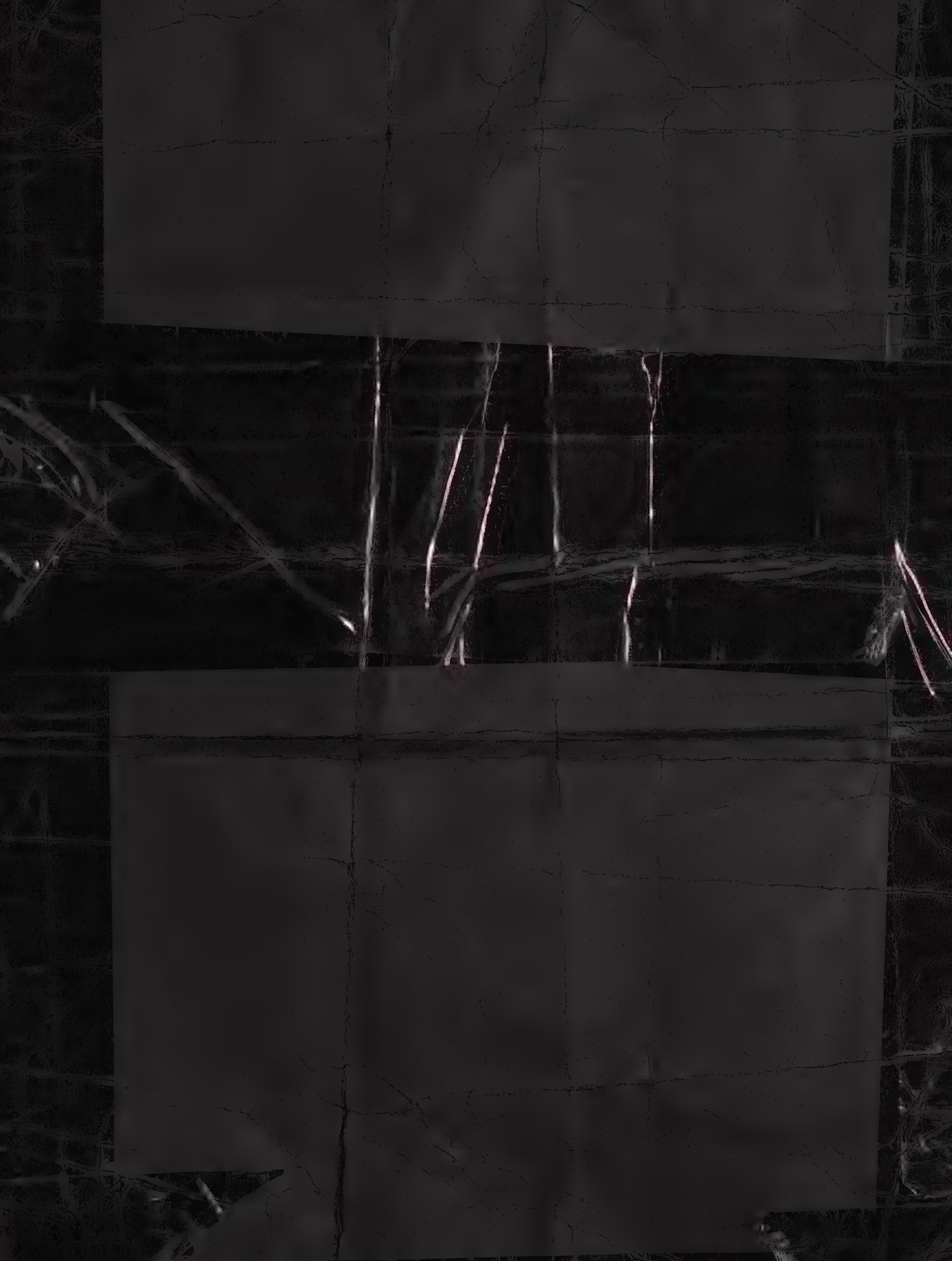
LEFT PAGE	RIGHT PAGE
CHASSIS ASSEMBLY D154-000	CHASSIS SCHEMATIC D154-200
MAIN BOARD ASSEMBLY D154-015 1 of 2	MAIN BOARD ASSEMBLY D154-015 2 of 2
MAIN BOARD SCHEMATIC D154-215 1 of 3	MAIN BOARD SCHEMATIC D154-215 2 of 3
MAIN BOARD SCHEMATIC D154-215 3 of 3	MOTHER BOARD ASSEMBLY D154-010
15 V, 24 V POWER SUPPLY ASSEMBLY D154-011	15 V, 24 V POWER SUPPLY SCHEMATIC D154-211
6 V, 23 V POWER SUPPLY ASSEMBLY D154-021	6 V, 23 V POWER SUPPLY SCHEMATIC D154-221
D-A CONVERTER ASSEMBLY D154-013	D-A CONVERTER SCHEMATIC D154-213
FREQUENCY RANGING BOARD ASSEMBLY D154-012	FREQUENCY RANGING BOARD SCHEMATIC D154-212
D-A AMPLIFIER ASSEMBLY D154-014	D-A AMPLIFIER SCHEMATIC D154-214
VCG BOARD ASSEMBLY D154-016	VCG BOARD SCHEMATIC D154-216
TRANSISTOR BOARD ASSEMBLY D154-017	EXTENDER BOARD ASSEMBLY B154-018
REAR PANEL ASSEMBLY D154-001	

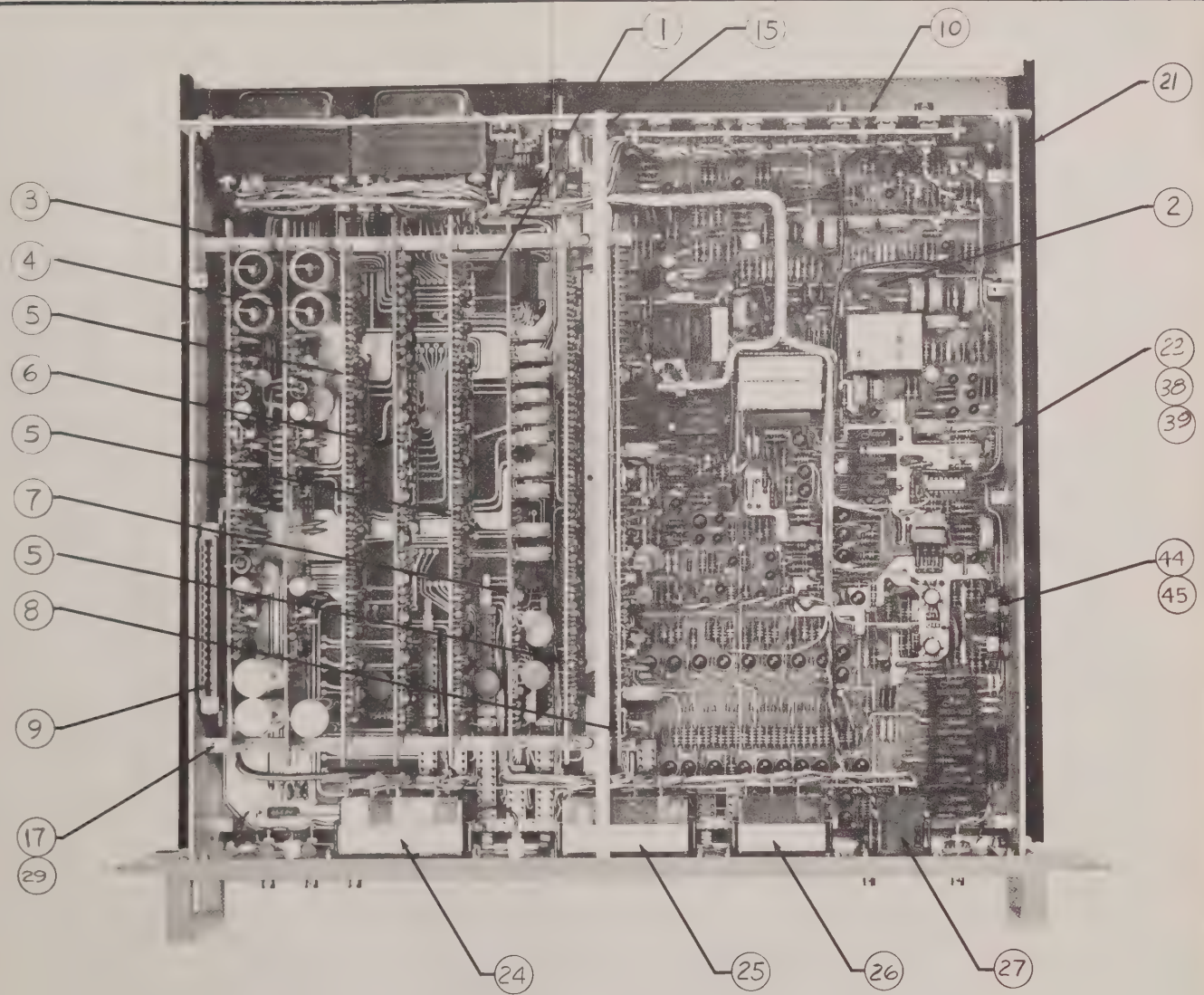
5.4 RECOMMENDED SPARE PARTS LIST

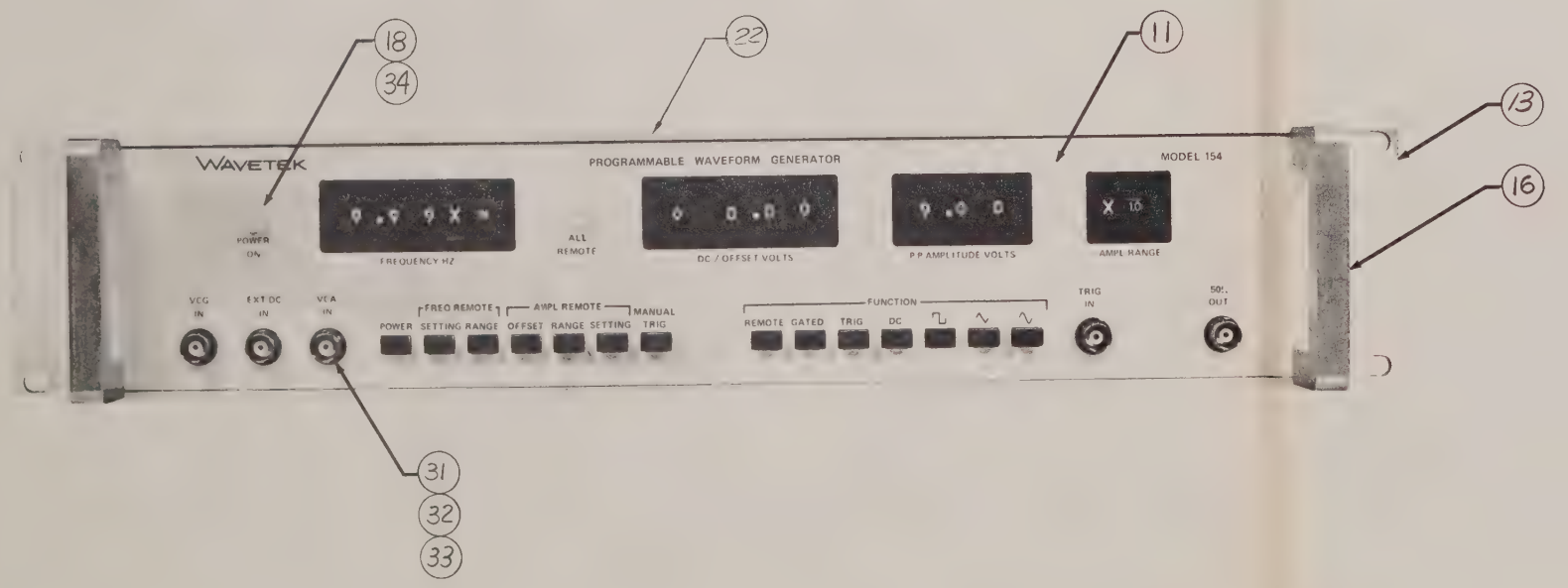
Information is provided to maintain the instrument on a board or component level. Price and delivery information should be obtained from the Wavetek representative in your area or directly from the factory.

DESCRIPTION	MFG	PART NO.	QTY
BOARD LEVEL			
15 V, 24 V POWER SUPPLY BOARD	WAVETEK	154-011	1
FREQ RANGING BOARD	WAVETEK	154-012	1
D/A CONVERTER BOARD	WAVETEK	154-013	1
D/A AMPLIFIER BOARD	WAVETEK	154-014	1
VCG BOARD	WAVETEK	154-016	1
6 V, 23 V POWER SUPPLY BOARD	WAVETEK	154-021	1
COMPONENT LEVEL			
DIODE TUNNEL	GE	1N3716	1
DIODE	SEMTECH	SCE-1	2
DIODE	FAIRCHILD	FD777	1
DIODE	FAIRCHILD	FD6666	8
★DIODE –69	FAIRCHILD	FD6666	2
DIODE ZENER	WAVETEK	130-506	2
FUSE ½A 115 V	LITTELFUSE	313-500	1
FUSE ¼A 230 V	LITTELFUSE	313-250	
★INTEGRATED CKT –13	FAIRCHILD	μA709C	2
★INTEGRATED CKT –14	FAIRCHILD	μA709C	2
INTEGRATED CKT	RCA	CA3028A	1
INTEGRATED CKT	RCA	CA3049	1
INTEGRATED CKT	MOTOROLA	MC1595L	1
INTEGRATED CKT	MOTOROLA	MC3050P	1
LAMP	MURA	BP 28/40	2
RELAY	JENCO	RR30-1023	2
RELAY	JENCO	RR30-1024	2
SINE MODULE	WAVETEK	B142-011	1
TRANSISTORS	FAIRCHILD	2N3638	8
TRANSISTORS	FAIRCHILD	2N3642	2
TRANSISTORS	FAIRCHILD	2N3646	8
TRANSISTORS	FAIRCHILD	2N4248	2
TRANSISTORS	MOTOROLA	MPS L08	1
TRANSISTORS	MOTOROLA	2N2905A	1
★TRANSISTORS –52	MOTOROLA	2N3563	2
★TRANSISTORS –53	MOTOROLA	2N5485	2
★TRANSISTORS –54	MOTOROLA	2N5485	1
★TRANSISTORS –55	MOTOROLA	2N5462	1
★TRANSISTORS –66	MOTOROLA	2N2219A	2
TRANSISTORS	TEXAS INST	TIP 29	2
TRANSISTORS	TEXAS INST	TIP 30	2
TRANSISTORS	TECH PROD	TP 308	1

★ Denotes special selected parts and should be ordered from Wavetek.







PARTS LIST

	ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO	QTY
	1		MOTHER BOARD ASSY	WAVETEK	D154-010	1
	2		MAIN BOARD ASSY		D154-015	1
	3		POWER SUPPLY ASSY ±26, ±15		D154-011	1
	4		+6, +23		D154-021	1
	5		D/A CONVERTER ASSY		D154-013	3
	6		FREQ RANGING ASSY		D154-012	1
	7		D/A AMPLIFIER ASSY		D154-014	1
	8		VCG BOARD ASSY		D154-016	1
	9		EXTENDER BD		D154-018	1
	10		REAR PANEL ASSY		D154-001	1
	11		FRONT PANEL		C154-300	1
(REF)	12		EXTRUSION INSTALLATION		D154-003	
	13		SUB PANEL		D154-301	
NOT SHOWN	14		MAIN SUPPORT BAR		B154-304	1
	15		SUPPORT BAR		B154-305	1
	16		HANDLE		B154-320	2
	17		BOARD SPACER		B154-310	2
	18		INDICATOR LENS		A154-311	2
(REF)	19		CHASSIS BLOCK ASSY		D154-002	
	20		TOP COVER		C755-318	1
NOT SHOWN	21		BOTTOM COVER		C755-322	1
	22		TRIM, FRONT		B154-323	2
	23		SIDE PLATE		C154-303	2
	24	SW9	FREQUENCY Hz SWITCH	WAVETEK	A154-400	1
	25	SW10	DC OFFSET SWITCH		A154-401	1
X	26	SW11	P-P AMPLITUDE SWITCH		A154-402	1
	27	SW12	AMPLITUDE RANGE SWITCH		A154-403	1
	28		COVER SUPPORT		B755-321	2
	29		SPACER	WAVETEK	A144-305	2
	30					
	31	J6-J10	BNC	KING	KC7946	5
	32		SHOULDER WASHER	H.H. SMITH	2668	10
	33		SOLDER LUG		1497	5
	34		RETAINER	TRUARC	5305-31	2
	35					
	36					
NOT SHOWN	37		CONNECTORS	AMPHENOL	57-30360	2
	38		FASTENER (6-32)	BOOTS AIRCRAFT	721D-1006-32	4
	39		CHASSIS BLOCK	USECO	1591C-11	10
	40		LAMPS	MURA	L28/40	2
NOT SHOWN	41		POWER CORD	BELDEN	17258-S	1
NOT SHOWN	42		SCREW 4-40 x 3/8 (THRUSS HEAD BLACK OXIDE)			4
	43					
	44		HEATSINK	THERMALLOY	1103A	2
	45		WASHER, SHOULDER #4	H.H. SMITH	2661	2

rev	ecn	by	date	app.
G	ECN 730	CLC		
F	ECN 721	VW	8-21-73	
E	ECN 528		12-15-72	
D	ECN-483	BC	9-27-72	
C	ECN 435	[illegible]	6/6/72	
B	ECN 417	[illegible]	4/7/72	
A	ECN 401	PB	2/21/72	

tolerance unless otherwise specified .XXX ± .010 .XX ± .030

scale N/A

material N/A

finish N/A

WAVETEK san diego, calif

by BCHICHIO date 8-19-71 app. K.S.

title CHASSIS ASS'Y

model no. 154 | dwg no. D154-000 | rev G

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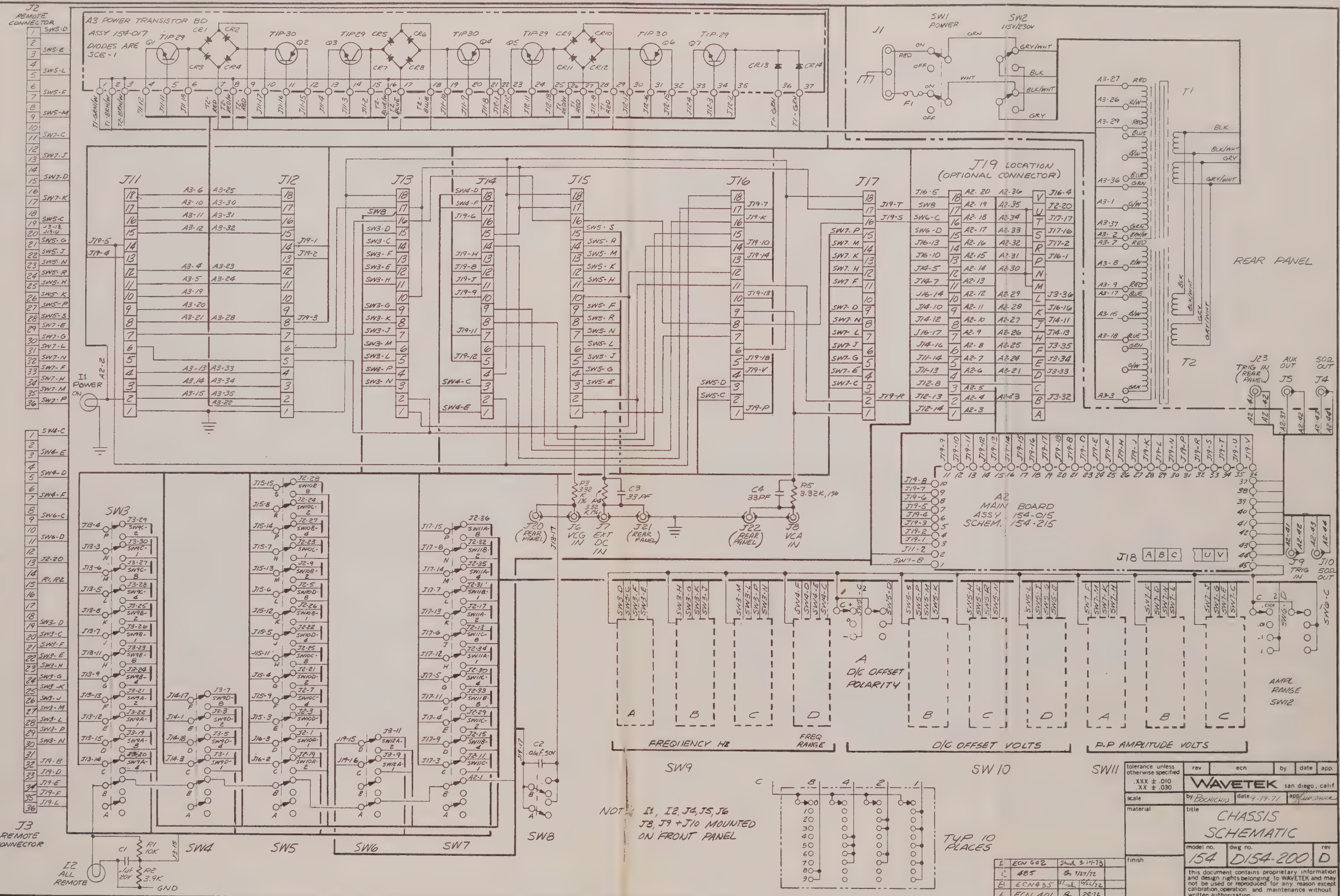

rev	ecn	by	date	app.
I	ECN 602	Shook	3-19-73	
H	485	Bo	1/27/72	
G	ECN 435	Shook	9/26/72	
F	ECN 401	Bo	2-8-72	

tolerance unless otherwise specified .XXX ± .010 .XX ± .030

scale

material

finish

WAVETEK san diego, calif.

by BOCHICHIO date 7-19-71 app.

title CHASSIS SCHEMATIC

model no. 154 dwg no. D154-200 rev D

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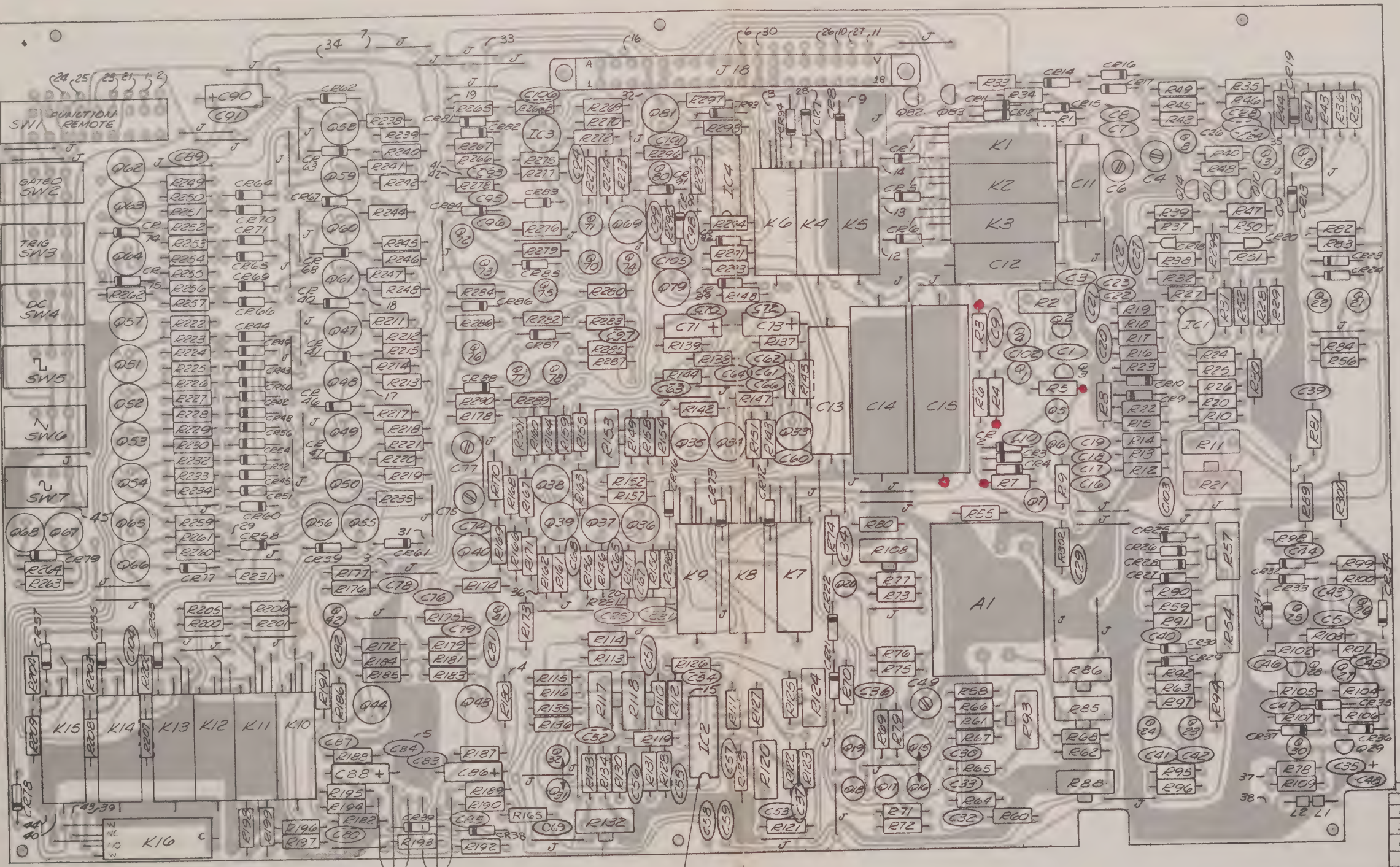

rev	ecn	by	date	app.
G	ECN 772	COX	6/30/75	
F	ECN 634	Shell	4-30-73	
E	ECN 575	B.R.	2-2-73	
D	ECN 529	Wanda	12-15-72	
C	ECN 481	BR	9/27/72	
B	ECN 435	Shell	6/26/72	
A	ECN 417	Shell	4/7/72	

tolerance unless otherwise specified .XXX ± .010 .XX ± .030

WAVETEK san diego, calif

scale 2/1 | by GRAY | date 8-30-71 | app. K.S.D.

material N/A

title ASSEMBLY, MAIN BOARD

finish N/A

model no. 154 | dwg no. SHEET 1 OF 2 0154-015 | rev G

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PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO.	QTY
1		CAPACITORS			
2	C40,C53 C64,C82, C93	CERAMIC DISC, 1000V, 10%, 5pF	CRL	DD050	5
3	C94	10pF		DD100	1
4	C37	15pF		DD150	1
5	C3, C44-C46, C67 C96, C99 C101	22pF		DD220	8
6	C2	SILVER MICA, 500V, 5% 30pF	ARCO	DM15-300J	1
7	C74	CERAMIC DISC, 1000V, 10% 30pF	CRL	DD300	1
8	C33	33pF		DD330	1
9	C97	47pF		DD470	1
10	C8	SILVER MICA, 500V, 1% 68pF	ARCO	DM15-680F	1
11	C29	CERAMIC DISC, 1000V, 10%, 68pF	CRL	DD680	1
12	C17, C22	SILVER MICA, 500V, 5% 91pF	ARCO	DM15-910J	2
13	C31	CERAMIC DISC, 1000V, 10% 100pF	CRL	DD101	1
14	C32	150pF		DD151	1
15	C19, C20	SILVER MICA, 500V, 5% 150pF	ARCO	DM15-151J	2
16	C30	CERAMIC DISC, 1000V, 10% 220pF	CRL	DD221	1
17	C65	330pF		DD331	1
18	C7	SILVER MICA, 500V, 1% 820pF	ARCO	DM15-821F	1
19					
20					
21	C18, C21	CERAMIC DISC, 1000V .001μF	CRL	DD102	2
22	C51	50V, 10% .005μF		CK-502	1
23	C9, C10, C25, C26, C28, C34, C36, C41, C42, C47, C52, C55, C57, C60, C63, C66, C68, C69, C70, C72, C74, C78, C79, C81, C83, C85, C87, C91, C95, C102, C104	.01μF		CK103	33
24	C83, C89	.1μF		CK104	2
25	C1, C24, C39, C43, C54, C58, C59, C103, C105, C106	20V, 10%, .1μF		UK20-104	10
26	C5, C27, C48, C56, C89	10V, 10%, .1μF		UK10-104	5
27	C11, C73, C86, C88, C90	TANTALUM, 35V, 10% 5.6μF	SPRAGUE	150D565X9035B2	5
28	C35, C95	15V, 22μF		196D226X9015KA1	2
29	C11	POLY, 100V, 1% .01μF	WAVETEK	130-501-6	1
30	C12	.1μF			1
31	C13	MYLAR, 200V, 1% 1μF			1
32	C14, C15	M. MYLAR, 10% 5μF			2
33	C4, C6, C49, C75, C77	7/35pF	STETTNER	7S-TRIKO-02 7/35	5
34	C16, C23	TRIM (SILVER MICA, 500V, 5%)			2
35					
36					
37		DIODES			
38	CR1, CR3 CR10 CR99, CR21 CR24, CR29 CR33 CR35 CR75, CR79, CR81, CR82, CR84 CR94	FD6666	FAIRCHILD	FD6666	77
39	CR14 CR17, CR25 CR28, CR34	FD777		FD777	9
40	CR2, CR13, CR83	ZENER	WAVETEK	130-506	3
41	CR18, CR20	TUNNEL IN3716	GE	IN3716	2
42	CR11, CR12	-58 FD777	FAIRCHILD	FD777	2
43					
44					
45	L1, L2	FERRITE BEADS	FERROX-CUBE	56 590 65/3B	2
46					

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO.	QTY
47		INTEGRATED CIRCUITS			
48	IC3	CA3028A	RCA	CA3028A	1
49	IC1	CA3049	RCA	CA3049	1
50	IC2	MC1595L	MOTOROLA	MC1595L	1
51	IC4	MC3050P	MOTOROLA	MC3050P	1
52					
53					
54	K6-K11, K16	RELAYS	JENCO	RR30-1023	7
55	K1-K5 K12-K15			RR30-1024	9
56					
57					
58					
59		RESISTORS			
60	R8, R9 R95, R96	CARBON, 1/2W, 5%, 8.2Ω	STACKPOLE	RC20GF8R2J	4
61	R86, R75, R76, R80 R84, R165, R192, R193	10Ω		100J	8
62	R143, R144 R187, R188	15Ω		150J	4
63	R1, R12 R19, R27, R31, R159, R164	22Ω		220J	7
64	R189, R190 R194, R195	27Ω		270J	4
65	R58, R74, R171, R300	33Ω		330J	4
66	R101, R102	47Ω		470J	2
67	R126	56Ω		560J	1
68	R169	62Ω		620J	1
69	R37, R50	91Ω		910J	2
70	R5, R6, R32, R34, R52, R81, R89, R102, R131, R154, R272, R274, R299	100Ω		101J	14
71	R111, R231	10%, 120Ω		121K	2
72	R236	5%, 200Ω		200J	1
73	R149, R170	10%, 220Ω		221K	2
74	R38, R39 R47, R51	5%, 240Ω		240J	4
75	R69, R110 R112, R119	10%, 270Ω		271K	4
76	R103	5% 390Ω		391J	1
77	R181, R184	10% 560Ω		561K	2
78	R269, R270	5% 820Ω		821J	2
79					
80					
81					
82	R106, R107	5% 1K		102J	2
83	R240, R248	5% 1.1K		112J	2
84	R24, R28	10% 1.2K		122K	2
85	R94, R97, R98, R285 R295	1.5K		152K	5
86	R26, R30	5% 1.6K		162J	2
87	R99	10% 1.8K		182K	1
88	R211, R217 R238, R240, R259	5% 2K		202J	5
89	R147, R157 R167, R279 R292, R301 R263, R264	10% 2.2K		222K	8
90	R35, R53, R282, R289	5% 2.4K		242J	4
91	R104	10% 2.7K		272K	1
92	R122	3.3K		332K	1
93	R7, R105 R161	3.9K		392K	3
94	R146, R271	5% 4.7K		472J	2
95	R291	10% 5.6K		562K	1
96	R225, R229	5% 6.2K		622J	2
97	R149	10% 6.8K		682K	1
98	R214, R17	5% 7.5K		752J	2
99	R282, R83, R123, R160, R172	10% 8.2K		822K	5
100	R13, R18, R140, R142, R174, R176, R179, R265, R266, R284, R286, R283, R287, R298	10K		103K	13

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO.	QTY
101		RESISTORS			
102	R153, R293, R294	CARBON, 1/2W, 10%, 15K	STACKPOLE	RC20GF153K	3
103	R163	5% 18K		183J	1
104	R224, R215, R225, R221, R240, R241, R246, R247, R261	10% 27K		273K	9
105	R223, R209, R216, R227, R229, R230, R233, R234, R250, R251, R253, R254, R256, R257	33K		333K	14
106	R121, R235, R216, R234, R240	47K		473K	5
107	R151	68K		683K	1
108	R60, R213, R219, R222, R225, R228, R232, R242, R248, R249, R252, R255, R262	100K		104K	13
109	R286	220K		224K	1
110					
111					
112					
113	R66, R67	METAL FILM, 1/4W, 1%, 21.5Ω	CORNING	RN60D	2
114	R196, R99 R209	49.9Ω			5
115	R208	51.1Ω			1
116	R200, R203	54.9Ω			2
117	R207	61.9Ω			1
118	R204, R206	71.5Ω			2
119	R302	82.5Ω			1
120	R78, R109	100Ω			2
121	R55	150Ω			1
123	R180, R186, R202	249Ω			3
124	R15, R16, R22, R23, R91, R182	316Ω			6
125	R70, R279	453Ω			2
126	R43, R48	499Ω			3
127	R42, R45, R61, R65	511Ω			4
128	R62, R215, R277	825Ω			3
129	R63, R71	56.2Ω			3
130					
131					
132	R114, R115	1K			2
133	R46	1.21K			1
134	R152, R168 R273	1.5K			3
135	R3, R183	1.62K			2
136	R191	1.78K			1
137	R125, R127, R133, R134	2K			4
138	R43, R68, R73, R130	2.37K			4
139	R59, R90, R203, R218	2.49K			4
140	R156, R162	2.87K			2
141	R150, R166, R178	3.01K			3
142	R4, R158	3.32K			2
143	R10, R20	3.65K			2
144	R296	3.83K			1
145	R137, R139, R175, R177	4.02K			4
146	R44	4.32K			1
147	R185	4.64K			1
148	R128, R139	6.98K			2
149	R63, R92	8.25K			2
150	R113, R116, R135, R136	10K			4
151	R297	15K			1
152	R212, R216, R239, R245, R260, R267	21.5K			6
153	R268	23.7K			1
154	R204	24.9K			1
155	R138, R175	38.3K			2
156					

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO.	QTY
157		RESISTORS			
158	R288	METAL FILM, 1/4W, 1% 100K	CORNING	RN60D	1
159	R281	237K			1
160					
161	R141, R171	-64 10K			2
162					
163					
164		POTENTIOMETERS			
165	R93, R108, R132, R153	100Ω	CRL	BA1603-B01	4
166	R2	250Ω		-021	1
167	R11, R21, R85, R286	500Ω		-802	4
168	R54, R57	1K		-803	2
169	R88, R117, R118	10K		-805	3
170	R104, R124	100K		-819	2
171					
172	J18	CONNECTOR	CINCH-JONES	252-18-30-160	1
173					
174	SW1-SW7	SWITCH ASSY	WAVETEK	154-404	1
175					
176					
177		TRANSISTORS			
178	Q43, Q46	2N2905A	MOTOROLA	2N2905A	2
179	Q5, Q41	2N3563		2N3563	2
180	Q33, Q35 Q37, Q39 Q47, Q54 Q58, Q66 Q68, Q69 Q79, Q81	2N3638	FAIRCHILD	2N3638	25
181	Q42, Q70, Q71	2N3640		2N3640	3
182	Q34, Q36, Q40, Q55, Q57, Q67	2N3642		2N3642	7
183	Q4, Q6, Q19, Q21, Q23, Q25, Q27, Q30 Q72-Q78, Q80	2N3646		2N3646	17
184	Q1, Q7, Q8, Q12, Q13, Q17, Q18, Q20, Q22, Q24	2N5139		2N5139	10
185	Q38	TO101	GE	TO101	1
186	Q9-Q11, Q14, Q26, Q29	MPS L08	MOTOROLA	MPS L08	6
187	Q44, Q45 -66	2N2219A		2N2219A	2
188	Q15, Q16 -52	2N3563		2N3563	2
189	Q82 -55	2N5462		2N5462	1
190	Q83 -54	2N5485		2N5485	1
191	Q2, Q3 -53	2N5485		2N5485	2
192	Q31 Q32 -52	2N3563		2N3563	2
193					
194	A1	SINE MODULE	WAVETEK	B142-011	1
195		CIRCUIT BOARD		154-115E	1
196		HEATSINK	WAKEFIELD	NF-207	2
197	IC2	SOCKET	CINCH	14-DIP	1

G	ECN 772	COK	10-11-73
F	ECN 654	Stuck	4-30-73
E	ECN 575	B.R.	2-2-73
D	529	Wands	12-15-72
C	401	BR	9-27-72
B	ECN 435	Stuck	9-6-72
A	ECN 417	Stuck	8-11-72

rev	ecn	by	date	app.

tolerance unless otherwise specified .XXX ± .010 .XX ± .030

scale —

material

finish

WAVETEK san diego, calif

by GRAY date 8-30-71 app.

title ASSY, MAIN BOARD

model no. 154 | dwg no. SHEET 2 OF 2 0154-015 | rev G

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COMPARATOR

HYS SWITCH

TRIANGLE AMPL

SQUARE AMPL

SYNC.

AUX AMPL

SINE AMPL

+24V

+15V

-15V

-24V

GND

R4 3.32K 1%

C102 .01µF

Q1 2N5139

R5 100Ω

Q5 2N3563

CR2 ZENER

C10 .01µF

Q6 2N3646

R8 8.2Ω

R11 500Ω

R10 3.65K 1%

TO VCG CONN PIN N, J18

J

C1 .1µF 20V

CR3

C16 TRIM

C17 91pF

C18 .001µF

C19 150pF

R12 22Ω

R13 10K

R14 7.5K

R15 316Ω, 1%

CR9

R22 316Ω 1%

R299 100Ω

CR13

IC1 CA3049

R23 3.16K 1%

R24 1.2K

R25 6.2K

R26 1.6K

R27 22Ω

R28 1.2K

R29 6.2K

R30 1.6K

R31 22Ω

C103 .1µF 20V

TO VCG CONN J18 PIN J

TO VCG CONN PIN K J18

Q82 2N5462

R32 100Ω

R33 100Ω

R35 2.4K

R36 200Ω

R37 91Ω

R38 240Ω

CR18 IN3716

R40 1.1K

R41 499Ω 1%

R43 2.37K 1%

R39 240Ω

Q12 2N5139

CR19

Q14 LO8

Q11 LO8 (2)

Q10 LO8

R44 4.32K 1% TRIM

R47 240Ω

CR20 IN3716

Q9 LO8

R50 97Ω

R51 240Ω

R52 100Ω

R53 2.4K

C27 .1µF 10V

C28 .01µF

R48 1.1K

CR14 FD777 (4)

CR16

CR17

CR15

R34 100Ω

Q83 2N5485

TO VCG CONN J18, PIN H

TO VCG CONN J18, PIN F

C24 .1µF 20V

Q8 2N5139

Q13 2N5139

R42 511Ω 1%

R45 511Ω 1%

R46 1.21K 1%

C26 .01µF 50V

R49 220Ω

C2 30 pF (TRIM)

Q2 * 2N5485 (2) Q3 *

C3 22pF

R2 250Ω

CR4

Q7 2N5139

R7 3.9K

R9 8.2Ω

R10, 316Ω, 1%

C20 150pF 1% R17

C21 .001µF

C22 91pF

R16 7.5K

R18 10K

R19 22Ω

C23 TRIM

CR10

R20 3.65K 1%

R21 500Ω

Q4 2N3646

C9 .01µF

R6 100Ω

R3 1.62K 1%

R1 22Ω

CR1

K1

CR5 K2 CR6 K3 CR7 K4 CR8 K5

C4 7/135 pF

C6 7/135pF

C7 820pF 1%

C8 68 pF 1% TRIM

C11 ≠≠ .01µF

C12 ≠≠ .1µF

C13 ≠≠ 1µF

C14 ≠≠ 5µF

C15 5µF

CR11

FD777 (2)

CR12

TO SHT3 "D"

TO FREQUENCY RANGING BOARD (PIN 16)

K6

CR94

-24V

TO VCG CONN (PIN R) J18

R62 825Ω 1%

R93 100Ω

R70 453Ω 1%

R71 56.2Ω 1% (2)

R72

R74 33Ω

R61 511Ω 1%

R65 511Ω 1%

R64

C33 270Ω 33pF

Q17 2N5139 (2)

Q18

R88 10K

R85 500Ω

R60 100K

R302 82.5Ω 1%

C36 .01µF

A1 WAVETEK 142-011

Q15 * 2N3563 (2)

Q16

Q19 2N3646

R58 33Ω

R75 10Ω

R80 10Ω

K7

K9

CR21

CR22

Q20 2N5139

R76 10Ω

C29 68 pF

R55 150Ω 1%

C32 150 pF

R66

R67 21.5Ω (2) 1%

GND

C34 .01 µF

R73 2.37K 1%

R77 33Ω

R86 500Ω

C30 220 pF

R68 2.37K 1%

R69 56.2Ω 1%

R108 100Ω

#C49 7/135 pF

R79 453Ω 1%

TO XY MULTIPLIER SHT 2 "A"

LAST REF DES

R302	A1
CR94	IC4
Q81	K16
C106	L2

R300 33Ω

R82 8.2K

Q21 2N3646

CR23

R84 10K

R54 1K

R59 2.49K 1%

CR25

CR27

FD777 (4)

CR28

R81 100Ω

CR26

R56 10Ω

CR24

Q22 2N5139

R83 8.2K

R90 2.49K 1%

R89 100Ω

R57 1K

C39 .1µF 20V

R94 1.5K

Q23 2N3646

C42 .01µF

CR29

R95 8.2Ω

R92 8.25K 1%

R96 8.2Ω

CR30

R91 316Ω 1%

C40 5pF

R63 8.25K 1%

R97 1.5K

C43 .1µF 20V

R99 1.8K

R100 100Ω

CR32

CR33

C44 22 pF

R98 1.5K

Q24 2N5139

Q25 2N3646

CR 31

C41 .01 µF

TO SHEET 3 "C"

C5 .1µF 10V

L1 L2

+6V

FERRITE BEADS (2)

CR34

FD777

R104 2.7K

R106 1K

CR36

C48 .1µF 10V

C35 22 µF 16V

Q26 2N3646

C45 22 pF

R101 47Ω

Q27 2N3646

R103 390Ω

CR35

R102 47Ω

C46 22pF

Q28 LO8

R78 100Ω 1%

J5 AUX OUT

R109 100Ω 1%

Q30 2N3646

R105 3.9K

R107 1K

CR37

C47 .01µF

C	ECN 575	B.R.	2-2-73	
B	ECN 435		4-4-72	
A	ECN 417		3-7-72	

tolerance unless otherwise specified	rev	ecn	by	date	app.
.XXX ± .010 .XX ± .030	WAVETEK san diego, calif				
scale N/A	by GRAY	date 7-2-71	app.		
material N/A	title SCHEMATIC, MAIN BOARD				
finish N/A	model no. 154	dwg no SHT. 1 OF 3 D154-215	rev C		

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A1 142-011

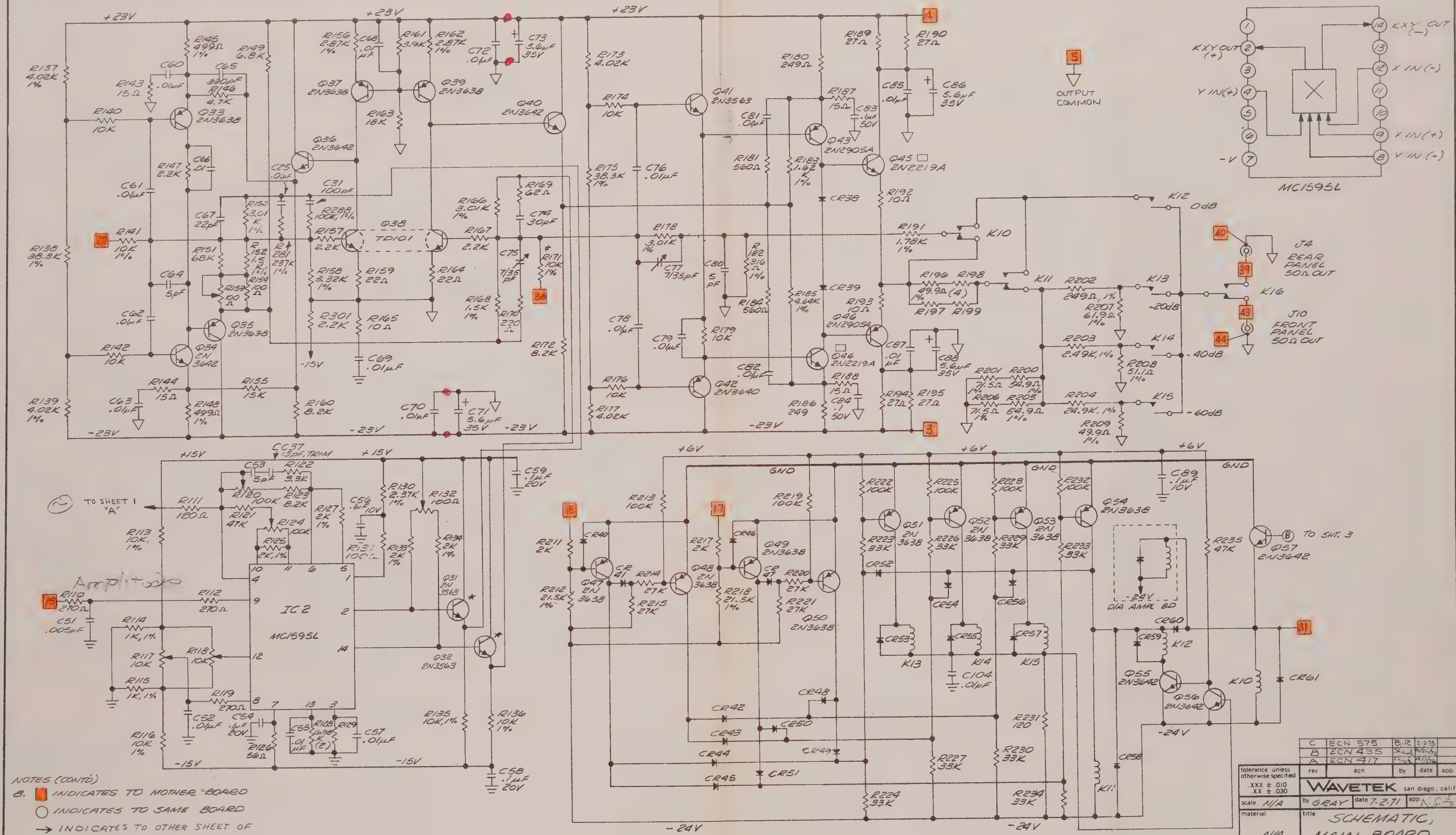
-V	01	40	+V
INPUT	02	50	OUTPUT
GND	03		

CA3049

NOTES: UNLESS OTHERWISE SPECIFIED:

1. DIODES ARE FDG666
2. RESISTORS ARE 1/2 W, 10%, CARBON
3. ★ INDICATES MATCHED PAIR TRANSISTORS Q2 & Q3, Q15 & Q16, Q31 & Q32
4. * INDICATES MATCHED PAIR RESISTORS R141 & R171
5. ≠≠ INDICATES MATCHED CAPACITOR SET C11 THRU C15
6. * INDICATES MATCHED PAIR DIODES CR11 & CR12
7. ⊠ INDICATES SELECTED TRANSISTOR Q44, Q45, Q82 AND Q83

(CONTD TO SHEET 2)



NOTES (CONTD)

8. ■ INDICATES TO MOTHER BOARD
   ○ INDICATES TO SAME BOARD
   → INDICATES TO OTHER SHEET OF MAIN BOARD SCHEMATIC

rev	ecn	by	date	app.
C	ECN 575	B.R	2-2-73	
B	ECN 435	[illegible]	9/25/72	
A	ECN 417	[illegible]	5/1/72	

tolerance unless otherwise specified .XXX ± .010 .XX ± .030

WAVETEK san diego, calif

scale N/A | by GRAY | date 7-2-71 | app [illegible]

material N/A

title SCHEMATIC, MAIN BOARD

model no. 154 | dwg no. SHT. 2 OF 3 D154-215 | rev C

finish N/A

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FUNCTION LOGIC

J18 VCG CONNECTOR

A	B	C	D	E	F	H	J	K	L	M	N	P	R	S	T	U	V
+15V	BASELINE OUTPUT	VCG INPUT	-15V	-24V	VCG OUTPUT TO 2N5885	" GATE	VCG OUTPUT TO 2N5912(G)	"	-24V	PROGRAM GND	CAPACITANCE MULT IN		CAP MULT CONTROL	X.001 Hz RANGE CONTROL	X.01Hz RANGE CONTROL	X1 HZ RANGE CONTROL	X1 Hz RANGE CONTROL

FUNCTION GATED TRIG DC

IC3 CA3028A

IC4 MC 3050P

CA3028A

TO VCG CONN J18, PIN B

TO SHEET 1 "D"

TO SHT 2

FRONT/REAR OUT

MOTHER BOARD

MANUAL TRIGGER

rev	ecn	by	date	app.
C	ECN 575	B.R.	2-2-73	
B	ECN 435		4/4/72	
A	ECN 417		9/1/72	

tolerance unless otherwise specified .XXX ± .010 .XX ± .030

scale –

material N/A

finish N/A

WAVETEK san diego, calif

by GRAY date 7-2-71 app K.S.L.

title SCHEMATIC, MAIN BOARD

model no. 154

dwg no. SHT 3 OF 3 D154-215

rev C

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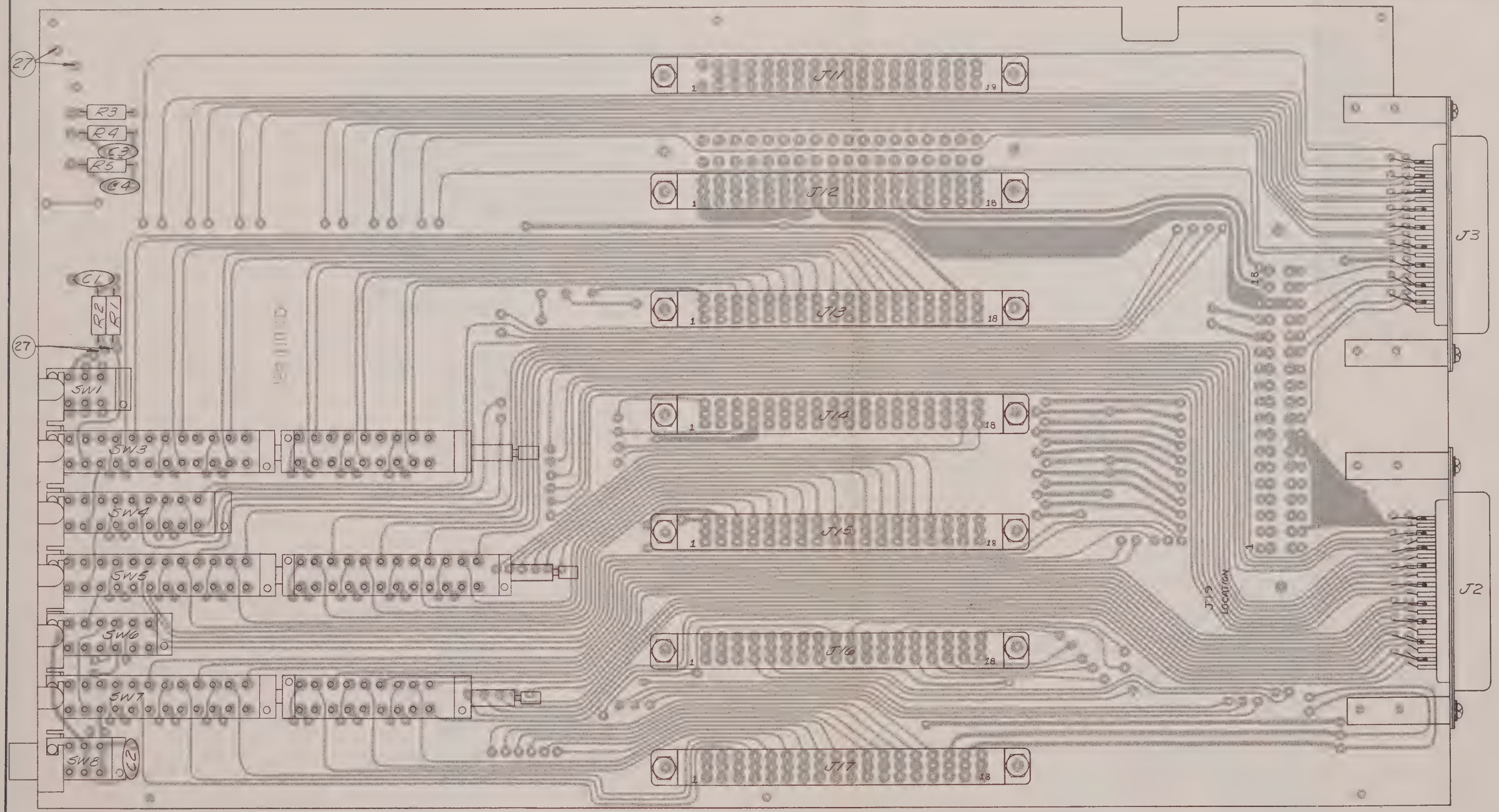

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO	QTY
1		CAPACITORS			
2	C3, C4	CERAMIC DISC, 1000V, 33pF	CRL	DD330	2
3	C2	50V, .01uF		CK103	1
4	C1	20V, .1uF		UK20-104	1
5					
6		RESISTORS			
7	R2	CARBON, 1/2W, 10%, 3.9K	STACKPOLE	RC20GF392K	1
8	R1	10K		103K	1
9					
10	R3-R5	METAL FILM, 1/4W, 1%, 3.32K	CORNING	RN60D	3
11					
12					
13					
14	SW1, SW3-SW8	SWITCH ASSY	WAVETEK	8154-405	1
15					
16					

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO.	QTY
17	J11-J17	CONNECTORS	CINCH	252-18-30-160	7
18	J2, J3		AMPHENOL	57-40360	2
19					
20					
21					
22					
23		CONNECTOR BLOCKS	WAVETEK	A154-306	4
24					
25					
26		CIRCUIT BOARD	WAVETEK	154-110C	1
27					2
28					
29					
30					
31					
32					
33					

rev	ecn	by	date	app.
D	ECN 528	L. Woods	12-15-72	
C	ECN 476	BG	9/27/72	
B	ECN 435	[illegible]	9/1/72	
A	ECN 417	[illegible]	4/7/72	

tolerance unless otherwise specified
.XXX ± .010
.XX ± .030

scale 2/1

material N/A

finish N/A

WAVETEK san diego, calif

by GRAY date 10-21-71 app. K. S

title ASSY, MOTHER BOARD

model no. 154

dwg no. 0154-010

rev D

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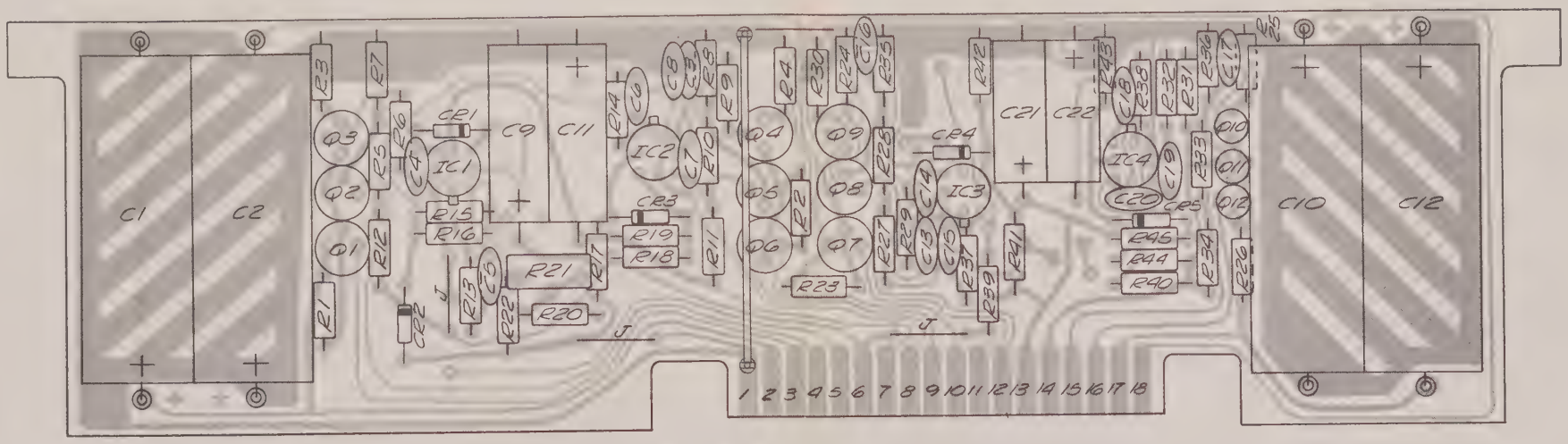


PARTS LIST

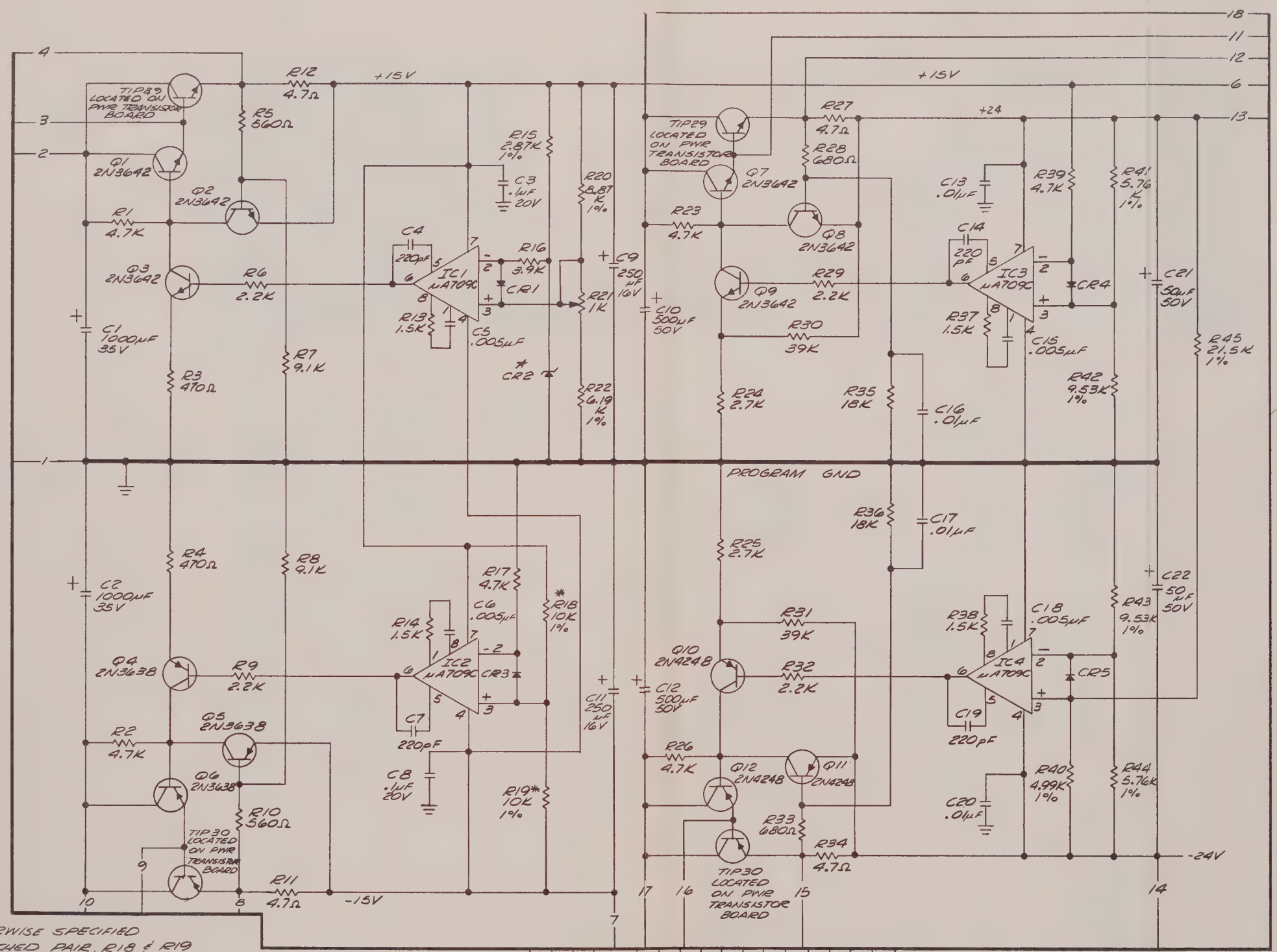
ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO.	QTY
1		CAPACITORS			
2	C4, C7, C14, C19	CERAMIC, 1000V, 10%, 220pF	CRL	DD221	4
3	C5, C6, C15, C18	50V, 10%, .005μF		CK-502	4
4	C13, C16, C17, C20	50V, 10%, .01μF		CK-103	4
5	C3, C8	20V, 10%, .1μF		UK20-104	2
6	C21, C22	ELECTROLYTIC, 50V, 10%, 50μF	SPRAGUE	500D506B050CD7	2
7	C9, C11	16V, 10%, 250μF		500D257D016DF7	2
8	C10, C12	50V, 10%, 500μF		39D507G050DK4	2
9	C1, C2	35V, 10%, 1000μF		39D108G035EL4	2
10					
11					
12		DIODES			
13	CR2	ZENER	WAVETEK	130-506	1
14	CR1, CR3-CR5	FD6666	FAIRCHILD	FD6666	4
15					
16					
17		INTEGRATED CIRCUITS			
18	IC1-IC4	-14 μA709C	FAIRCHILD	μA709C	4
19					
20					
21		POTENTIOMETER			
22	R21	1K		BA1603-803	1
23					
24					
25		RESISTORS			
26	R11, R12, R27, R34	CARBON, 1/2 W, 5%, 4.7Ω	STACKPOLE	RC20GF4R7J	4
27	R3, R4	10%, 470Ω		471K	2
* 28	R5, R10	560Ω		561K	2
29	R28, R33	680Ω		681K	2
30	R13, R14, R37, R38	1.5K		152K	4
31	R6, R9, R29, R32	2.2K		222K	4
32	R24, R25	2.7K		272K	2
33	R16	3.9K		392K	1
34	R1, R2, R17, R23, R26, R39	5% 4.7K		472J	6
35	R7, R8	5%, 9.1K		912J	2
36	R35, R36	5%, 18K		183J	2
37	R30, R31	10%, 39K		393K	2
38					
39					
40					
41					
42					
43					

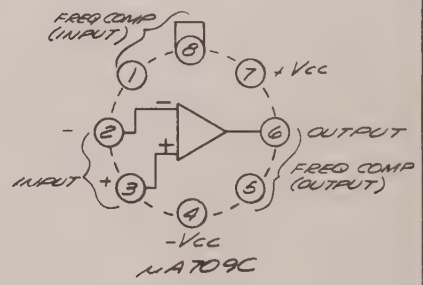
PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO.	QTY
44		RESISTORS			
45	R15	METAL FILM, 1/4W, 1%, 2.87K	CORNING	RN60D	1
46	R40	4.99K			1
47	R41, R44	5.76K			2
48	R22	6.19K			1
49	R20	8.87K			1
50	R42, R43	9.53K			2
51	R45	21.5K			1
52					
53					
54	R18, R19	-64 10K			2
55					
56					
57		TRANSISTORS			
58	Q4, Q5 Q6	2N3638	FAIRCHILD	2N3638	3
59	Q1-Q3 Q7-Q9	2N3642		2N3642	6
60	Q10-Q12	2N4248		2N4248	3
61					
62					
63					
64		CIRCUIT BOARD	WAVETEK	154-111B	1
65		STAND OFF	ITRON	316-0137-2 DASH A	2
66					
67					
68					
69					
70					

NOTE: R5 & R10;
WHEN USING 1/8 WATT RESISTORS
THESE VALUES SHOULD BE 68KΩ

	A	477		8/9/71	
tolerance unless otherwise specified .XXX ± .010 .XX ± .030	rev	ecn	by	date	app
	WAVETEK san diego, calif				
scale 2/1	by GRAY	date 6-22-71	app. K.L.		
material N/A	title ASSEMBLY, 15V, 24V POWER SUPPLY				
	model no. 154	dwg no. D154-011	rev A		
finish N/A	This document contains proprietary information and design rights belonging to WAVETEK and may not be used or reproduced for any reason except calibration, operation and maintenance without written authorization.				





NOTES: UNLESS OTHERWISE SPECIFIED
1. * INDICATES MATCHED PAIR, R18 & R19
2. RESISTORS ARE CARBON, 1/2W, 10%
3. DIODES ARE FD6666
4. * ZENER DIODE SELECTED PER WAVETEK 130-506

LAST REF DESIG
R45 IC4
C22 Q12
CR5

rev	ecn	by	date	app
A	ECN 435	SCL	6/21/71	

tolerance unless otherwise specified .XXX ± .010 .XX ± .030

WAVETEK san diego, calif

scale N/A | by GRAY | date 5-26-71 | app K.S.P.

material N/A

title: SCHEMATIC, 15V, 24V POWER SUPPLY

model no. 154 | dwg no. D154-211 | rev A

finish N/A

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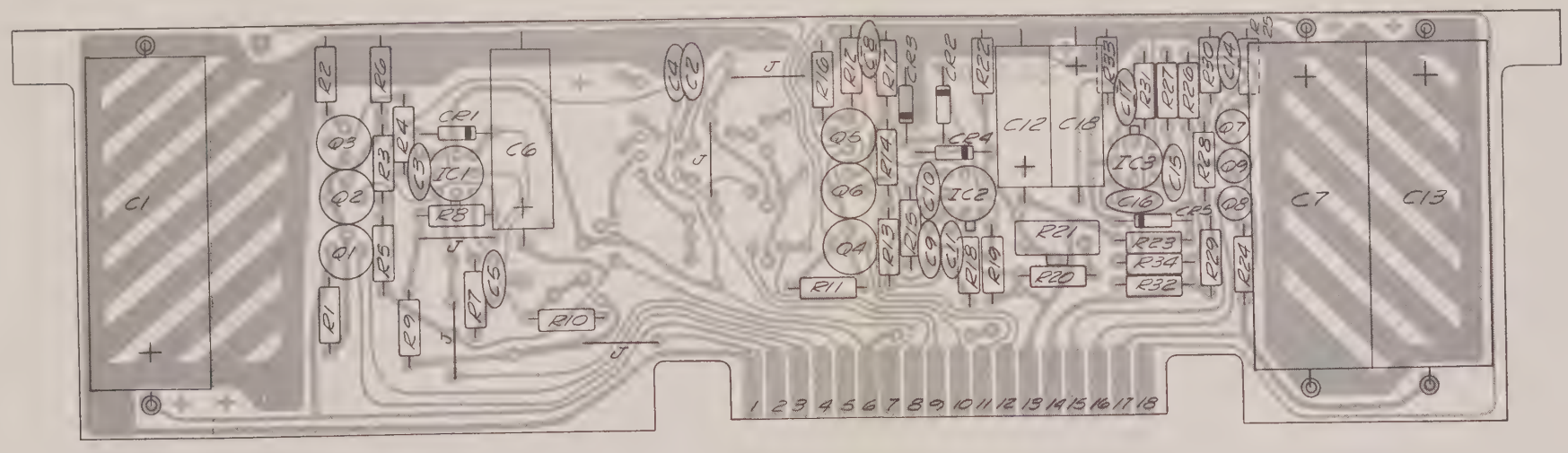

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO.	QTY
1		CAPACITORS			
2	C3, C10 C15	CERAMIC, 1000V, 10%, 220pF	CRL	DD221	3
3	C5, C11, C17	50V, .005μF		CK-502	3
4	C8, C9, C14, C16	50V .01μF		CK-103	4
5	C2, C4	20V .1μF		UK20-104	2
6	C12, C18	ELECTROLYTIC, 50V, 10%, 50μF	SPRAGUE	500D506G050DD2	2
7	C6	16V, 250μF		5DCD257B016DF7	1
8	C7, C13	50V 500μF		39D507G050GL4	2
9	C1	35V 1000μF		39D108G035GL4	1
10					
11					
12					
13		DIODES			
14	CR1, CR4, CR5	FD6666	FAIRCHILD	FD6666	3
15	CR2, CR3	ZENER	WAVETEK	130-506	2
16					
17					
18					
19		INTEGRATED CIRCUITS			
20	IC1-IC3	-14	FAIRCHILD	μA709C	3
21					
22					
23	R21	POTENTIOMETERS 1K	CRL	BA1603-803	1
24					
25					
26		RESISTORS			
27	R5, R13, R29	CARBON, 1/2W, 5%, 4.7Ω	STACKPOLE	RC20GF4R7J	3
28	R2	10% 470Ω		471K	1
29	R3	560Ω		561K	1
30	R14, R28	680Ω		681K	2
31	R7, R18 R31	1.5K		152K	3
32	R4, R15, R27	2.2K		222K	3
33	R12, R25	2.7K		272K	2
34	R10, R19	3.9K		392K	2
35	R1, R11, R24	5% 4.7K		472J	3
36	R6	9.1K		912J	1
37	R17, R30	18K		183J	2
38	R16, R26	10% 39K		393K	2
39					
40					
41					
42					
43					

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO.	QTY
44		RESISTORS			
45	R9, R32	METAL FILM, 1/4W, 1%, 4.99K	CORNING	RN60D	2
46	R34	5.76K			1
47	R20	6.98K			1
48	R8	7.5K			1
49	R22, R33	9.53K			2
50	R23	21.5K			1
51					
52					
53					
54		TRANSISTORS			
55	Q1-Q6	2N3642	FAIRCHILD	2N3642	6
56	Q7-Q9	2N4248		2N4248	3
57					
58					
59					
60					
61		CIRCUIT BOARD	WAVETEK	154-111B	1
62					
63					
64					
65					
66					
67					

tolerance unless otherwise specified .XXX ± .010 .XX ± .030

rev	ecn	by	date	app.

WAVETEK san diego, calif

scale 2/1 | by GRAY | date 6.21.71 | app. K.C.D.

material N/A

finish N/A

title: ASSEMBLY 6V, 23V POWER SUPPLY

model no. 154 | dwg no. 0154-021 | rev

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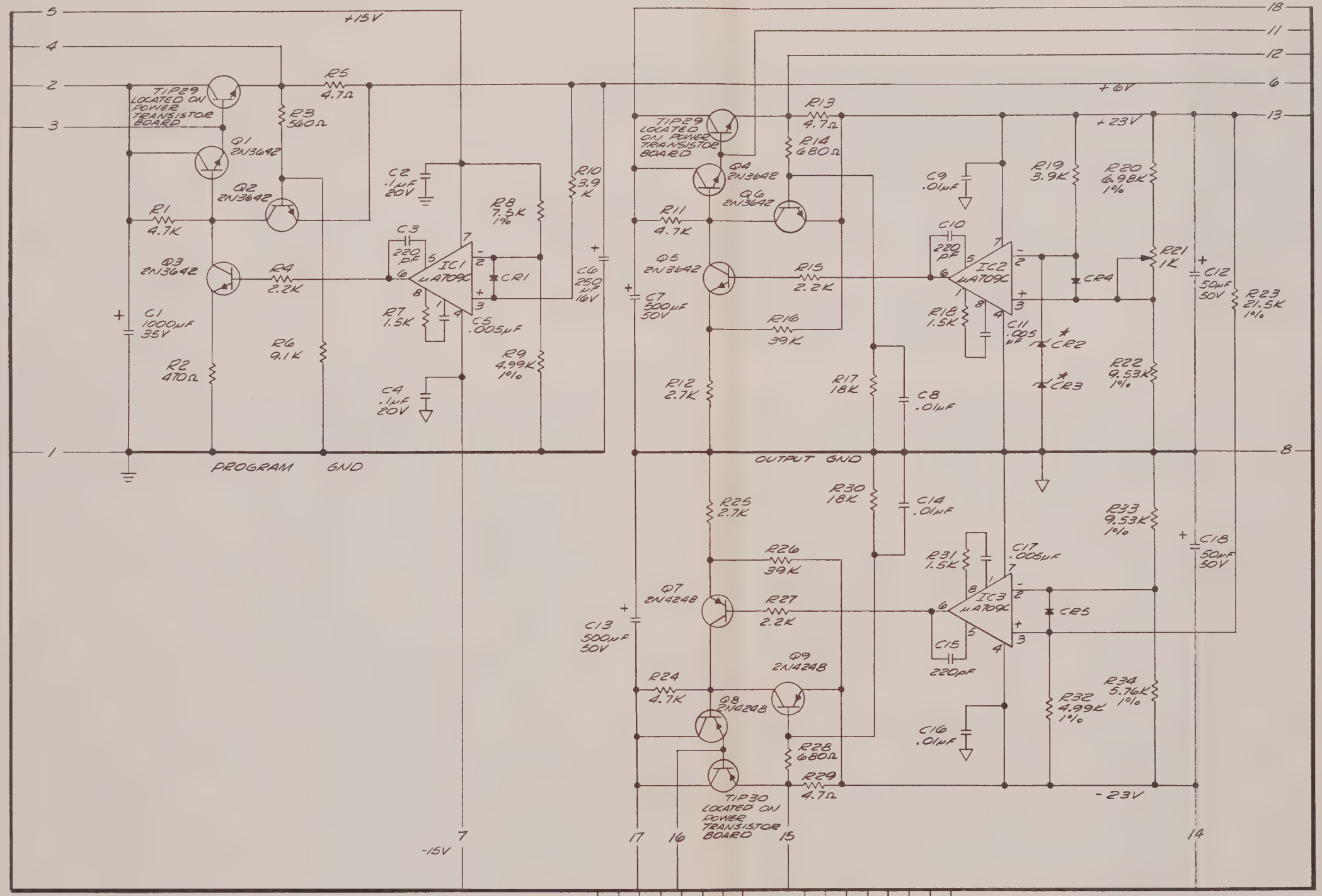

NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTORS ARE CARBON, 1/2W, 10%
2. DIODES ARE FD6666
3. ZENER DIODE SELECTED PER WAVETEK 130-506

REF DESIG.		
R34	CR5	
C18	Q9	
IC3		

rev	ecn	by	date	app.
A	ECN 435	[illegible]	9/21/72	

tolerance unless otherwise specified: .XXX ± .010, .XX ± .030

WAVETEK san diego, calif

scale N/A | by GBAY | date 5-28-71 | app KSL

material: N/A

finish: N/A

title: SCHEMATIC 6V, 23V POWER SUPPLY

model no. 154 | dwg no. D154-221 | rev A

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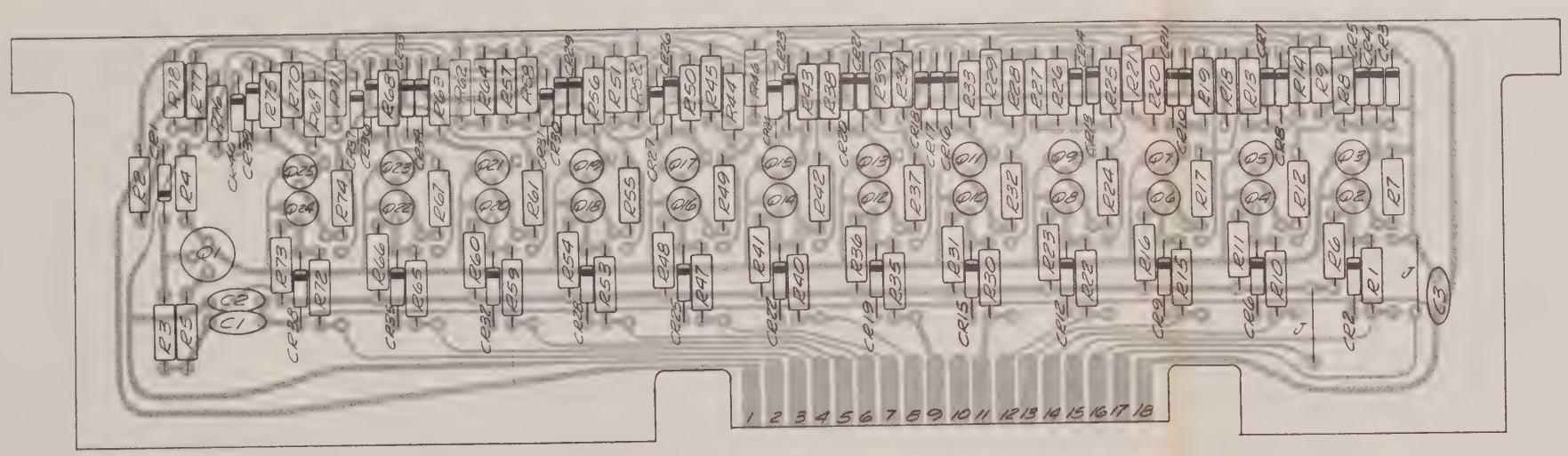

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO.	QTY
1		CAPACITORS			
2	C3	CERAMIC DISC, 10V, 10%, .1μF	CRL	UK10-104	1
3	C1, C2	20V,		UK20-104	2
4					
5					
6		DIODES			
7	CR1, CR2, CR6, CR9, CR12, CR15, CR19, CR22, CR25, CR28-CR40	FD6666	FAIRCHILD	FD6666	22
8	CR3-CR5, CR16-CR18	-69			6
9	CR7, CR8, CR10, CR11, CR13, CR14	-69			6
10	CR20, CR21, CR23, CR24, CR26, CR27	-69			6
11					
12					
13		RESISTORS			
14	R5	CARBON, 1/2W, 10% 680Ω	STACKPOLE	RC20GF681K	1
15	R1, R10, R15, R22, R30, R35, R40, R47, R53, R59, R65, R72	5% 2.4K		242J	12
16	R7, R12, R17, R24, R32, R37, R42, R49, R55, R61, R67, R74	10% 10K		103K	12
17	R4	5% 18K		183J	1
18	R56, R75	10% 22K		223K	2
19	R6, R14, R16, R23, R31, R36, R41, R48, R54, R60, R66, R73, R76	5% 24K		243J	13
20	R50, R63, R68	30K		303J	3
21	R52, R58, R62, R71	10% 47K		473K	4
22	R78	8.2K		822K	1
23	R46	10% 220K		224K	1
24					
25					

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO.	QTY
26	R2	METAL FILM, 1/4W, 1%, 124Ω	CORNING	RN60D	1
27	R3, R8	4.64K			2
28	R13, R18, R19	6.98K			3
29					
30	R25	27.4K			1
31	R33	46.4K			1
32	R38, R43	69.8K			2
33					
34	R51	402K			1
35	R57, R64, R69, R70, R77	1M			5
36					
37					
38	R9, R14, R20, R21, R26, -R29	-67 10K			8
39	R34, R39, R44, R45	-68 100K			4
40					
41					
42					
43		TRANSISTORS			
44	Q1	2N3638	FAIRCHILD	2N3638	1
45	Q2-Q25	2N3646		2N3646	24
46					
47					
48					
49		CIRCUIT BOARD	WAVETEK	154-1138	1
50					
51					
52					

rev	ecn	by	date	app.
4	ECN 476	GS	7-27-72	

tolerance unless otherwise specified: .XXX ± .010, .XX ± .030

scale 2/1

material: N/A

finish: N/A

WAVETEK san diego, calif

by GRAY date 6-11-71 app. K.S.

title: ASSEMBLY, D-A CONVERTER

model no. 154 | dwg no. 0154-013 | rev A

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NOTES: UNLESS OTHERWISE SPECIFIED:
1. ALL DIODES ARE FD666
2. RESISTORS 1/2W, 10%, CARBON
3. TEANSISTORS ARE 2N3640
4. ✱ ; □, △ ARE FD666 IN MATCHED SETS. OF 6
5. ☒ ARE 10K, 1%, MATCHED SET OF 8
6. ⊗ ARE 100K, 1%, " " 4

LAST REF DESIG.
Z78 C3
C2A0 Φ25

P13
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

D/A CONVERTER OUTPUT
1 2 4 8 10 20 40 80 100 200 400 800
+15V IN
-15V IN
+5V IN
PROGRAM GROUND

15 17 2 16 8 18 6 13 5 12 4 11 7 14 3 9 1

-15V
PROGRAM GND
+15V
+6V

A	ECN 435	SWK	10/4/72		
rev	ecn	by	date	app.	

tolerance unless otherwise specified
.XXX ± .010
.XX ± .030

WAVETEK san diego, calif

scale N/A	by GRAY date 6-7-71 app. K.S.
material N/A	title SCHEMATIC D/A CONVERTER
finish N/A	model no. 154 dwg no. D154-213 rev A

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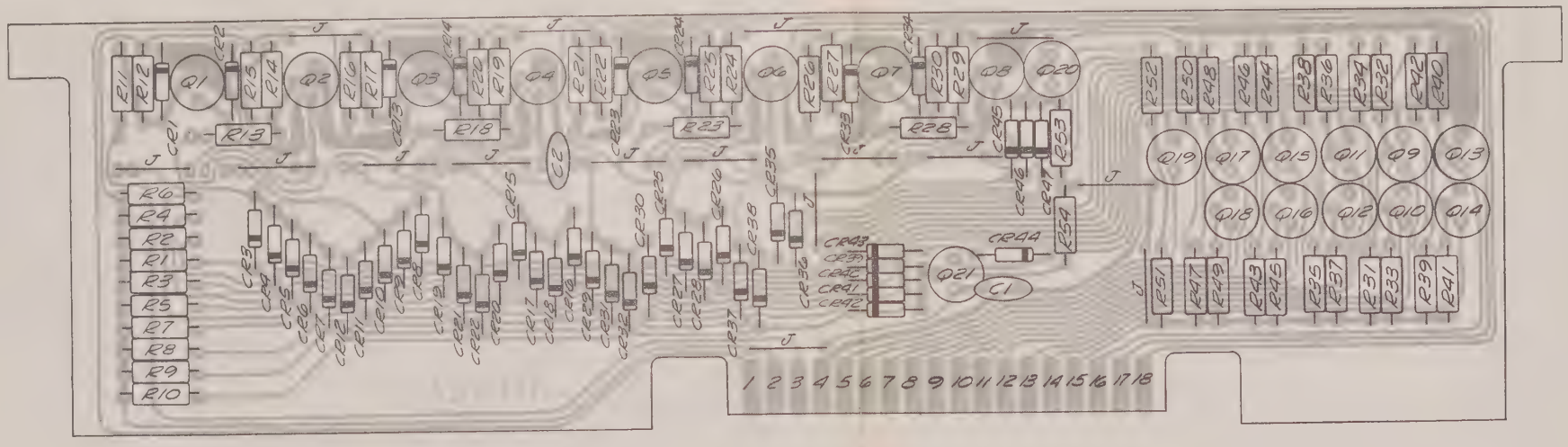

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO.	QTY
1		CAPACITORS			
2	C1	CERAMIC DISC 50V, 10%, .01μF	CRL	CK-103	1
3	C2	" " 10V, " .1μF	"	UK10-104	1
4					
5					
6		DIODES			
7	CR1-CR47	FD6666	FAIRCHILD	FD6666	47
8					
9					
10		RESISTORS			
11	R11, R16, R21, R26	CARBON, 1/2W, 5% 2K	STACKPOLE	RC20GF202J	4
12	R12, R15, R19, R20, R24, R25, R29, R30	" " 10% 27K		273K	8
13	R1-R10, R32, R34, R36, R38, R40, R42, R44, R46, R48, R50, R52	" " " 33K		333K	21
14	R13, R18, R23, R28, R31, R33, R35, R37, R39, R41, R43, R45, R47, R49, R51	" " " 100K		104K	15
15	R53, R54	" " " 220K		224K	2
16					
17					
18	R12, R17, R22, R27	METAL FILM, 1/4W, 1%, 21.5K	CORNING	RN60D	4
19					
20					
21					
22	Q1-Q21	TRANSISTOR 2N3638	FAIRCHILD	2N3638	21
23					
24					
25					
26		CIRCUIT BOARD	WAVETEK	154-112A	1
27					
28					
29					

tolerance unless otherwise specified .XXX ± .010 .XX ± .030	rev	ecn	by	date	app
	WAVETEK san diego, calif				
scale 2/1	by GRAY	date 6-16-71	app K. S. P.		
material N/A	title ASSEMBLY FREQ RANGING				
finish N/A	model no. 154	dwg no. D154-012	rev		

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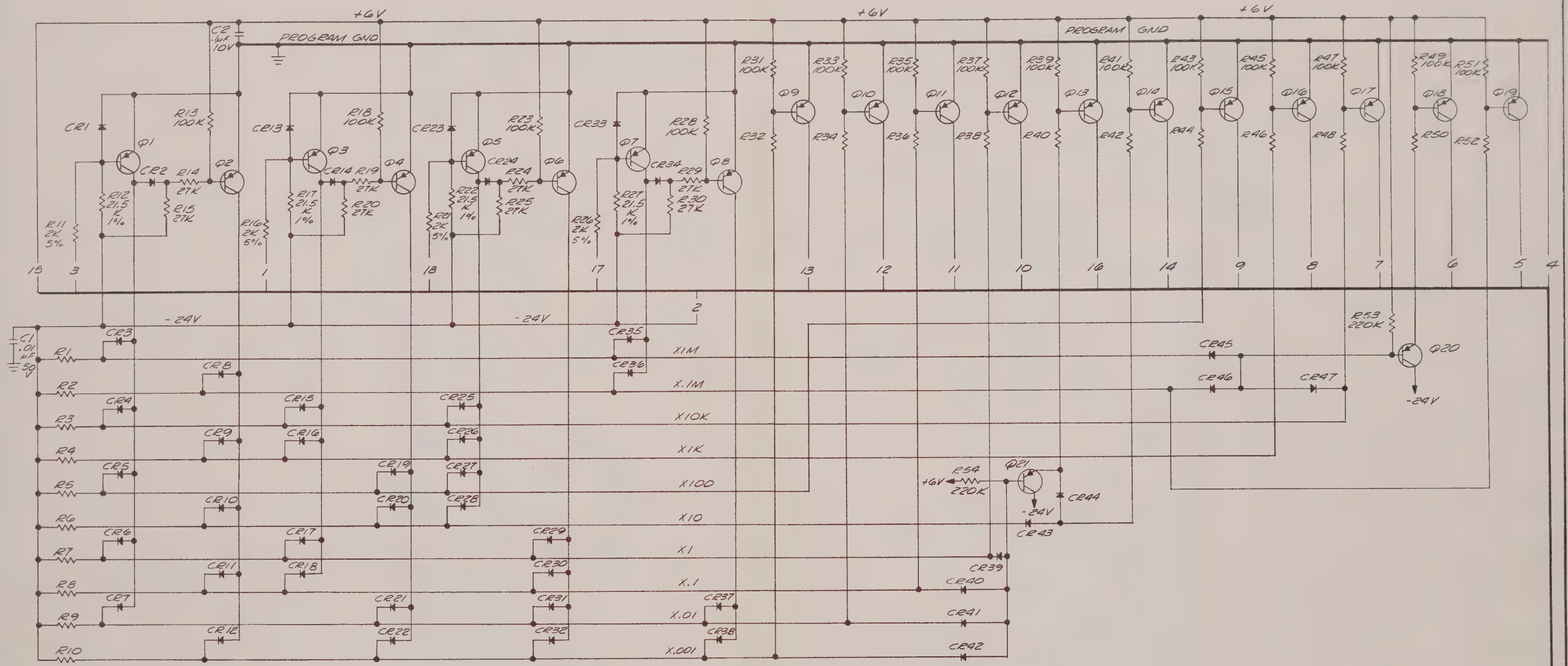
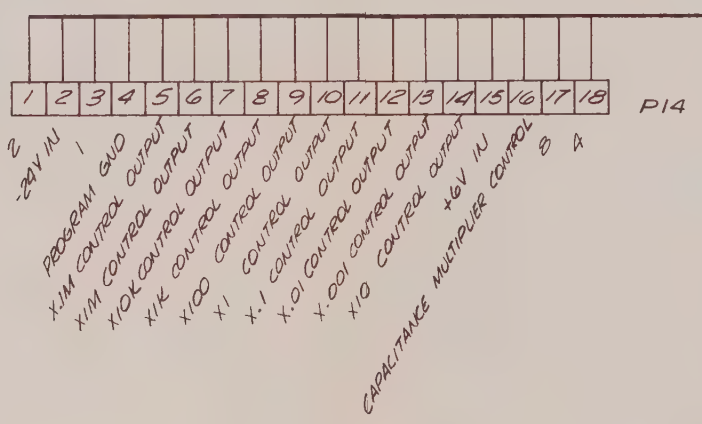


NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE 1/2W, 10%, CARBON
2. ALL RESISTORS ARE 33K
3. ALL TRANSISTORS ARE 2N3638
4. ALL DIODES ARE FD6666



LAST REF DESIG
R54
CR47
Q21
C2

A	ECN 435	SL	9/24/71		
rev	ecn	by	date	app	

tolerance unless otherwise specified: .XXX ± .010, .XX ± .030
scale N/A
material N/A
finish N/A

WAVETEK san diego, calif
by GRAY date 6-9-71 app. K.S.L.

title: SCHEMATIC, FREQUENCY RANGING
model no. 154
dwg no. D154-212
rev A

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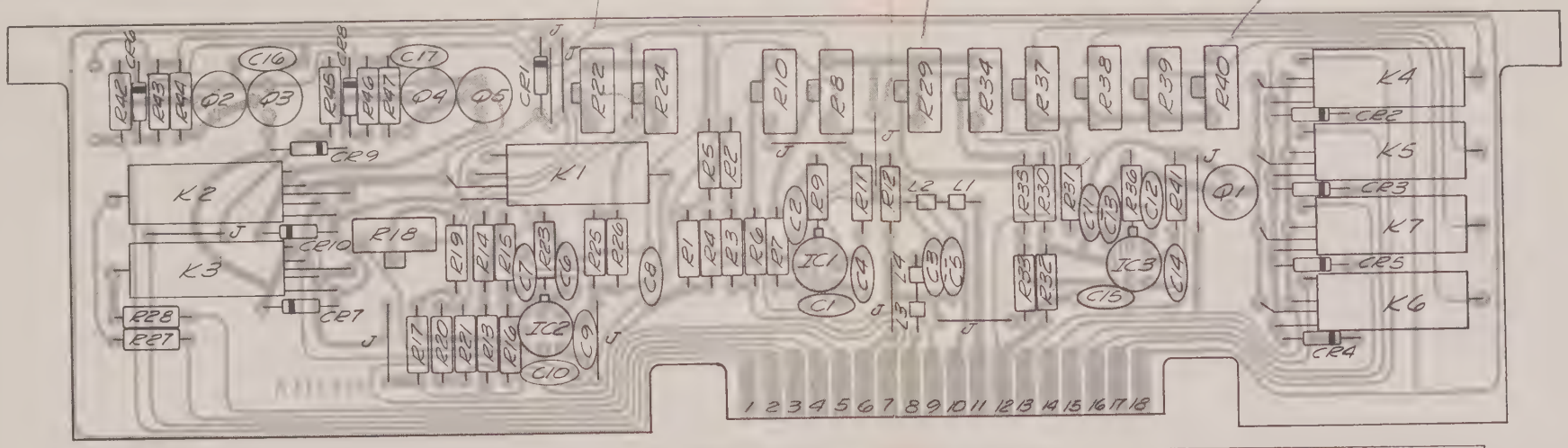

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO	QTY
1		CAPACITORS			
2	C1	CERAMIC DISC, 1000V 10pF	CRL	DD100	1
3	C7	22pF		DD220	1
4	C11	33pF		DD330	1
5	C4, C9, C14	220pF		DD221	3
6	C2, C6, C13	.005μF		CK502	3
7	C17	50V, 10% .01μF		CK103	1
8	C3, C5, C8, C10, C12, C15, C16	20V, .1μF		UK20-104	7
9					
10					
11					
12	CR1-CR10	DIODES FD6666	FAIRCHILD	FD6666	10
13					
14					
15		POTENTIOMETERS			
16	R10, R22, R24, R37, R40	250Ω	CRL	BA1603-021	7
17	R8, R18, R29, R34	100K		-819	4
18					
19					
20	K2, K3	RELAYS	JENCO	RR30-1023	2
21	K1, K4-K7			-1024	5
22					
23					
24		RESISTORS			
25	R3, R16, R32	CARBON, 1/2W, 10% 180Ω	STACKPOLE	RC20GF181K	3
26	R41	680Ω		681K	1
27	R9, R23, R36	1.5K		152K	3
28	R42, R45	5% 2K		202J	2
29	R11, R12	10% 2.2K		222K	2
30	R4, R17, R33	5% 5.1K		512J	3
31	R1, R13	10%, 10K		103K	2
32	R44, R47	27K		273K	2
33	R5, R14	150K		154K	2
34	R21, R26	180K		184K	2
35	R30	2.2M		225K	1
36	R2, R7, R15, R19, R35	6.8M		685K	5
37					
38					
39					

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO.	QTY
40		RESISTORS			
41	R6	METAL FILM, 1/4W, 1% 1.21K	CORNING	RN60D	1
42	R31	3.32K			1
43	R20, R25	6.19K			2
44	R27, R28	10K			2
45	R43, R46	21.5K			2
46					
47					
48		INTEGRATED CIRCUITS			
49	IC1-IC3	-13 μA709C	FAIRCHILD	μA709C	3
50					
51					
52					
53	L1-L4	FERRITE BEADS	FERROXCUBE	56-590-65/3B	4
54					
55					
56					
57		TRANSISTORS			
58	Q1-Q5	2N3638	FAIRCHILD	2N3638	5
59					
60					
61					
62					
63		CIRCUIT BOARD	WAVETEK	154-114A	1
64					
65					
66					
67					
68					
69					
70					

tolerance unless otherwise specified .XXX ± .010 .XX ± .030	rev	ecn	by	date	app.
scale 2/1	WAVETEK san diego, calif				
material N/A	by GRAY	date 6-15-71	app. K.S.		
finish N/A	title ASSEMBLY D-A AMPLIFIER				
	mode no 154	dwg no D154-014	rev		

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AMPLITUDE D/A AMPLIFIER

FREQUENCY D/A AMPLIFIER

DC/OFFSET D/A AMPLIFIER

PROGRAM GROUND

OFFSET CONTROL LOGIC

L1 L2 → +15V

L3 L4 → -15V

R1 10K
R2 6.8M
R3 180Ω
R4 5.1K
R5 150K
R6 1.21K 1%
R7 6.8M
R8 100K
R9 1.5K
R10 250Ω
R11 2.2K
R12 2.2K
C1 10pF
C2 .005 µF
C3 .1µF, 20V
C4 220pF
C5 .1µF 20V
C16 .1µF 20V
IC1 µA709C

R13 10K
R14 150K
R15 6.8M
R16 180Ω
R17 5.1K
R18 100K
R19 6.8M
R20 6.19K 1%
R21 180K
R22 250Ω
R23 1.5K
R24 250Ω
R25 6.19K 1%
R26 180K
R27 10K 1%
R28 10K 1%
C6 .005 µF
C7 22pF
C8 .1µF 20V
C9 220pF
C10 .1µF 20V
IC2 µA709C
CR1
K1
K2
K3

R29 100K
R30 2.2M
R31 3.32K 1% (TRIM)
R32 180Ω
R33 5.1K
R34 100K
R35 6.8M
R36 1.5K
R37 250Ω
R38 250Ω
R39 250Ω
R40 250Ω
R41 680Ω
C11 33pF
C12 .1µF 20V
C13 .005 µF
C14 220pF
C15 .1µF 20V
C17 .01µF
IC3 µA709C
Q1 2N3638
K4
K5
K6
K7

-24V
CR2
CR3
CR4
CR5
17
16
14
15

13

CR6
CR8
Q2 2N3638 (2)
Q4 2N3638 (2)
Q3
Q5
R42 2K
R43 21.5K 1%
R44 27K
R45 2K
R46 21.5K 1%
R47 27K
CR7
CR9
CR10
K3
K2
-24V

11 8 6 9 7 5 4 1 10 12 2 3 18

P16

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

1. DC/OFFSET AMP GAIN CONTROL
2. DC/OFFSET POLARITY LOGIC INPUT
3. DC/OFFSET POLARITY LOGIC INPUT
4. DC/OFFSET D/A AMP OUTPUT
5. DC/OFFSET D/A AMP OUTPUT
6. PROGRAM GROUND
7. DC/OFFSET D/A AMP INPUT
8. -15V IN
9. AMPLITUDE D/A AMP INPUT
10. AMPLITUDE D/A AMP OUTPUT
11. +15V IN
12. FREQUENCY D/A AMP INPUT
13. FREQUENCY D/A AMP OUTPUT
14. X1K FREQ CALIB CONTROL
15. X10K FREQ CALIB CONTROL
16. X100 FREQ CALIB CONTROL
17. X10 FREQ CALIB CONTROL
18. -24V IN

LAST REF DESIG

R47	Q5
C17	K7
CR10	IC3
	L4

FREQ COMP (INPUT) 1 · 8 · 7 +Vcc
INPUT 2 − 3 + · 6 OUTPUT
4 -Vcc · 5 FREQ COMP (OUTPUT)
µA709C

NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTORS, CARBON, 1/2W, 10%
2. DIODES ARE FDG666

rev.	ecn	by	date	app.
A	ECN 435	Stark	9/24/71	

tolerance unless otherwise specified .XXX ± .010 .XX ± .030

WAVETEK san diego, calif

scale N/A | by GRAY | date 6-3-71 | app

material N/A

finish N/A

title SCHEMATIC, D/A AMPLIFIERS

model no. 154 | dwg no. D154-214 | rev A

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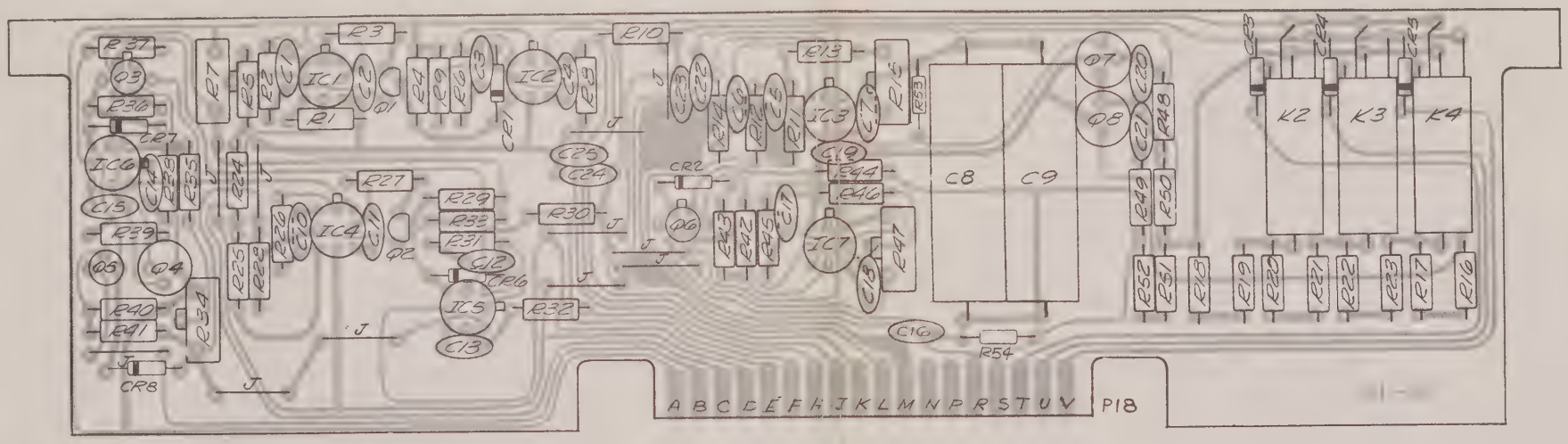

PARTS LIST

ITEM	REF DES	DESCRIPTION			MFGR	MFGR NO.	QTY
1		CAPACITORS					
2	C18	CERAMIC, 1000V, 10%,		47pF	CRL	DD470	1
3	C2,C4,C5, C7,C11, C13,C15			220pF		DD221	7
4	C19,C20			470pF		DD471	2
5	C16,C17			.001μF		DD102	2
6	C1,C3,C6 C10,C12, C14		50V	.005μF		CK502	6
7	C21, C23, C25, C26			.01μF		CK103	8
8	C22,C24		20V	.1μF		UK20-104	2
9	C8,C9	M.MYLAR	1%	5μF	WAVETEK	130-501-7	2
10							
11							
12							
13	CR1-CR8	DIODES	FD6666		FAIRCHILD	FD6666	8
14							
15							
16							
17		INTEGRATED CIRCUITS					
18	IC1-IC7	-13	μA709C		FAIRCHILD	μA709C	7
19							
20							
21							
22		POTENTIOMETERS					
23	R15			500Ω	CRL	BA1603-802	1
24	R7, R34, R47			100K	CRL	-819	3
25							
26							
27	K2-K4	RELAYS			JENCO	RR30-1024	3
28							
29							
30		TRANSISTORS					
31	Q8			2N3638	FAIRCHILD	2N3638	1
32	Q4, Q7			2N3642		2N3642	2
33	Q5			2N4248		2N4248	1
34	Q2	-55		2N5462	MOTOROLA	2N5462	1
35	Q1	-54		2N5485		2N5485	1
36	Q3, Q6			TP308	TECH. PROD.	TP308	2
37							
38							
39							

PARTS LIST

ITEM	REF DES	DESCRIPTION			MFGR	MFGR NO.	QTY
40		RESISTORS					
41	R52	CARBON, 1/2W, 5%, 10Ω			STACKPOLE	RC20GF100J	1
42	R49			82Ω		820J	1
43	R44			5%, 150Ω		151J	1
44	R50			10%, 680Ω		681K	1
45	R12			820Ω		821K	1
46	R1, R25, R48			5% 1K		102J	3
47	R2, R3, R4, R8, R14, R26, R27, R31, R32, R38, R45			10%, 1.5K		152K	11
48	R41			1.8K		182K	1
49	R40			5%, 18K		183J	1
50	R5, R46			10%, 470K		474K	2
51	R10, R30			6.8M		685K	2
52	R35			220K		224K	1
53							
54	R39	METAL FILM, 1/4W, 1%, 499Ω			CORNING	RN600	1
55	R11			1K			1
56	R51			1.1K			1
57	R13			4.99K			1
58	R16 R17 R22 R23 R20 R21 R18 R19		-50	1K 10K 100K 1M			8
59	R9, R33		-49	1K			2
60	R4, R24		-49	1K			2
61	R28, R29		-49	1K			2
62	R42, R43			15K			2
63	R36 R37			10K			2
64		CIRCUIT BOARD			WAVETEK	154-1160	1
65							
66		RESISTORS (CONT)					
67	R54	METAL FILM, 1/8W, 1%, 1K			CORNING	RN55D	1
68	R53			4.99K	CORNING	RN55D	1
69							
70							
71							
72							
73							

rev	ecn	by	date	app.
B	ECN 575	B.R.	2-6-73	
A	ECN 435	[illegible]	9/14/72	

tolerance unless otherwise specified .XXX ± .010 XX ± .030

scale 2/1

material N/A

finish N/A

WAVETEK san diego, calif

by GRAY date 8-23-71 app K.S.

title ASSEMBLY, VCG BOARD

model no. 154

dwg no. D154-016

rev B

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VCG

+15V +24V -24V

C1 .005µF · R2 1.5K · IC1 µA709C · C2 220pF · -15V · R1 1K

* R4 1K 1% · R9* 1K 1% · CR1 · IC2 µA709C · C4 220 pf · C3 .005µF · R6 1.5K · R8 1.5K

R3 1.5K · Q1 2N5485 · R5 470K · R7 100K

C25 .01µF · C24 .1µF 20V · R10 6.81MΩ

GND

R13 4.99K 1% · R15 500Ω · R12 820Ω · R53 4.99K · IC3 µA709C · C7 220pF · C6 .005 µF · R14 1.5K · -15V · C5 220pF · R11 1K 1%

CAPACITANCE MULTIPLIER

R18 1M, 1% · R19 1M, 1% · R20 100K 1% · R21 100K 1% · R22 10K 1% · R23 10K 1% · CR3 K2 · CR4 K3 · CR5 K4 · C8 5µF · C9 5µF · R16 1K, 1% · R17 1K, 1% · C23 .01µF

R34 100K · C16 .001µf

Q3 ½ TP308 · R35 220K · R36 10K 1% · R38 1.5K · C14 .005µF · CR8 · C22 .1µF 20V · IC6 µA709C · C15 220pF · Q4 2N3642 · R39 499Ω 1% · Q5 2N4248 · R37 10K 1% · R41 1.8K · R40 18K

Q6 TP308 · R44 150Ω · C19 470pF · Q7 2N3642 · CR2 · C20 470pF · IC7 µA709C · C18 47pF · R48 1K · R50 680Ω · R51 1.1K 1% · R52 10Ω · R · C21 0.01µF · R42 15K 1% · R43 15K 1% · C17 .001µF · R46 470K · R47 100K · R45 1.5K · Q8 2N3638 · R49 82Ω · R54 1K

R28 ## 1K, 1% · R30 6.8M · R24 * 1K 1% · C10 .005µF · R26 1.5K · IC4 µA709C · R25 1K · C11 220pF · R27 1.5K · Q2 2N5462 · C12 .005µF · R31 1.5K · IC5 µA709C · CR6 · C13 220pF · R32 1.5K · ## R29 1K 1% · * R33 1K 1% · R37 10K 1%

-15V -24V

C F H D B

P18

A	B	C	D	E	F	H	J	K	L	M	N	P	R	S	T	U	V
+15V	BASELINE OUTPUT	VCG INPUT	-15V	-24V	VCG OUTPUT TO 2N5485	VCG OUTPUT TO 2N5485 (GATE)	VCG OUTPUT TO 2N5462 (GATE)	VCG OUTPUT TO 2N5462	+24V	PROGRAM GND	CAPACITANCE MULT IN	CAP. MULT CONTROL	X.001 HZ RANGE CONTROL	X.01 HZ RANGE CONTROL	X.1 HZ RANGE CONTROL	X1 HZ RANGE CONTROL	

L A E K J N S T U V M R

NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTORS ARE 1/2W, 10%, CARBON
2. * INDICATES MATCHED PAIR
3. ≠ INDICATES MATCHED PAIR
4. ## " " "
5. △ " " SET

LAST REF. DES.
R54 Q8
C25 IC7
CR8 K4

rev	ecn	by	date	app.
C	ECN 575	B.12	2-5-73	
B	ECN 435		9-24-71	
A	ECN 417		7-21-72	

tolerance unless otherwise specified .XXX ± .010 .XX ± .030

WAVETEK san diego, calif

scale N/A · by GRAY · date 6-23-71 · app K.S.H.

material N/A

title SCHEMATIC, VCG BOARD

model no. 134 · dwg no. D134-216 · rev C

finish N/A

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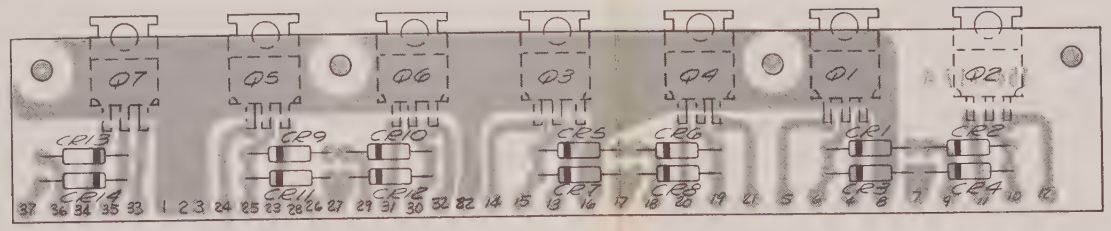
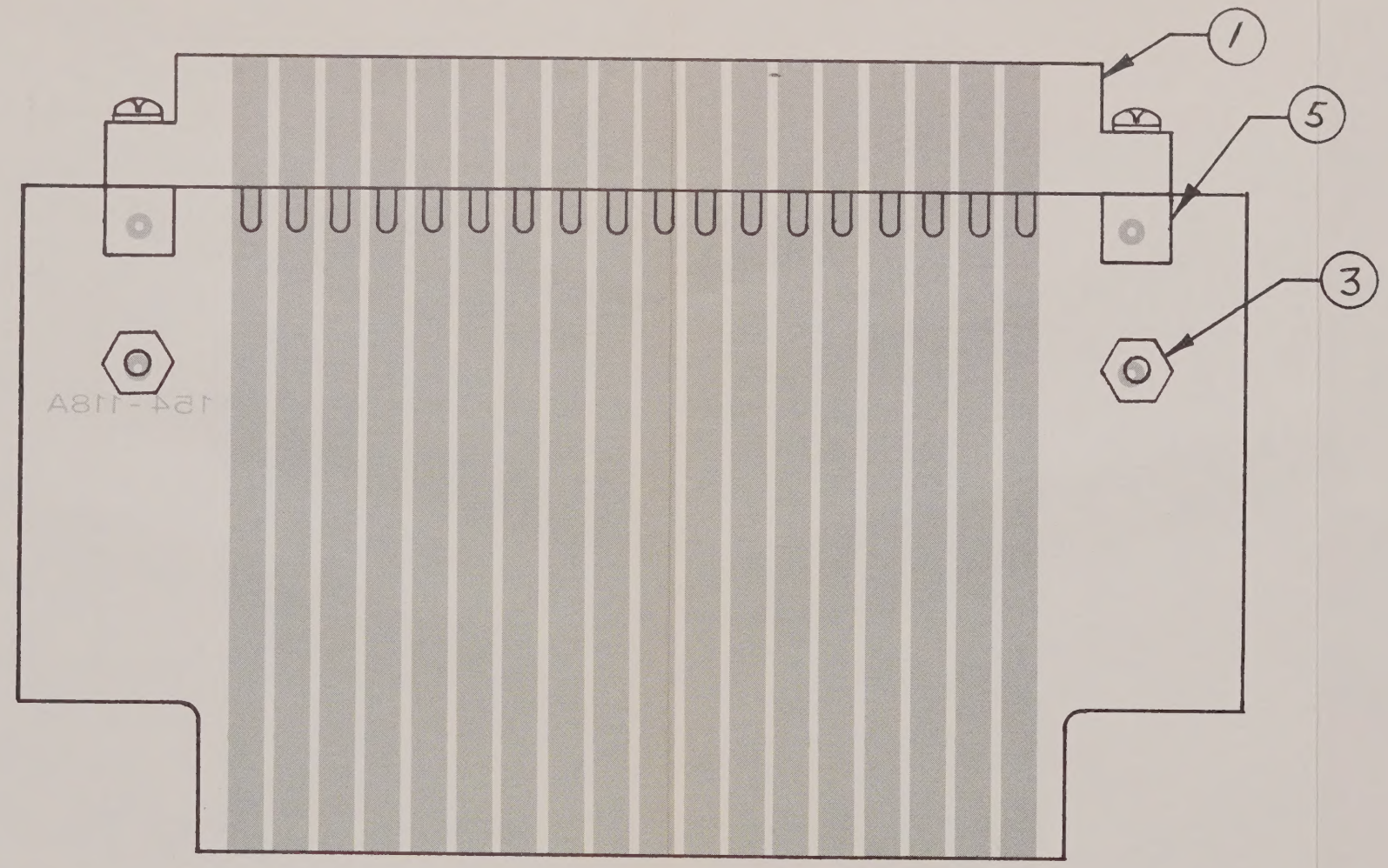


PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO.	QTY
1		DIODES			
2	CR1-CR14	SCE-1	SEMTECH		14
3					
4					
5		TRANSISTORS			
6	Q1,Q3, Q5,Q7	TIP 29	TEXAS INSTRUMENT	TIP 29	4
7	Q2,Q4,Q6	TIP 30		TIP 30	3
8					
9					
10		CIRCUIT BOARD	WAVETEK	154-117-A	1
11					
12					
13					

NOTES: UNLESS OTHERWISE SPECIFIED
1. TRANSISTORS MOUNTED ON CIRCUIT SIDE

tolerance unless otherwise specified .XXX ± .010 .XX ± .030	rev	ecn	by	date	app.
	WAVETEK san diego, calif				
scale 2/1	by GRAY	date 6-30-71	app. K.S.P.		
material N/A	title ASSEMBLY, TRANSISTOR MOUNTING BD				
	model no. 154	dwg no. 0154-017	rev		
finish N/A	this document contains proprietary information and design rights belonging to WAVETEK and may not be used or reproduced for any reason except calibration, operation and maintenance without written authorization.				



PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO.	QTY
1		CONNECTOR	CINCH	252-18-30-160	1
2					
3		STANDOFF	USECO	1531-B 3/8	2
4					
5		CHASSIS BLOCK	USECO	1591-B 11	2
6					
7					
8		P.C. BOARD	WAVETEK	154-118A	1
9					

TOLERANCE UNLESS OTHERWISE SPEC
XXX ± .010
XX ± .030
ANGLES ± 0 30

REV	ECN	BY	DATE	APP

WAVETEK SAN DIEGO, CALIF

SCALE 2/1 | BY GRAY | DATE 10-29-71 | APP

MATERIAL N/A

TITLE ASSY, EXTENDER 80

MODEL NO. 154 | DWG NO 8154-018 | REV

FINISH N/A

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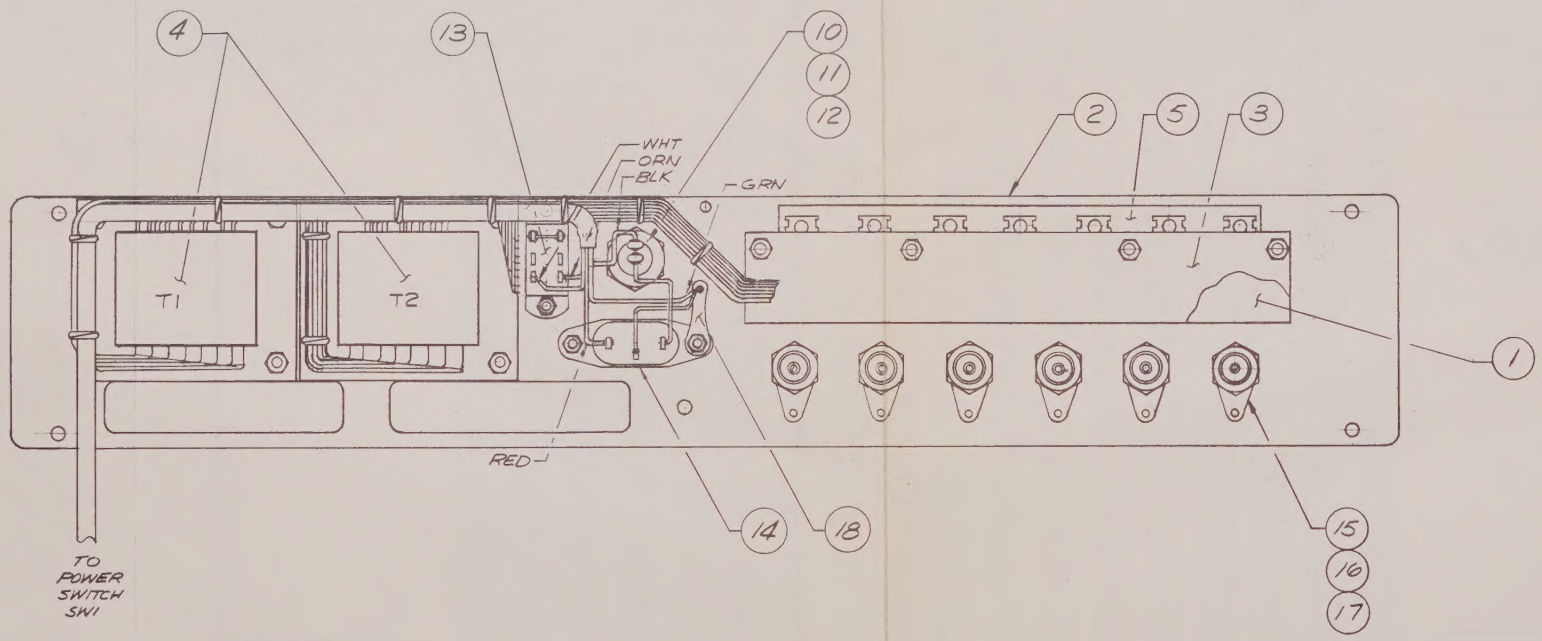

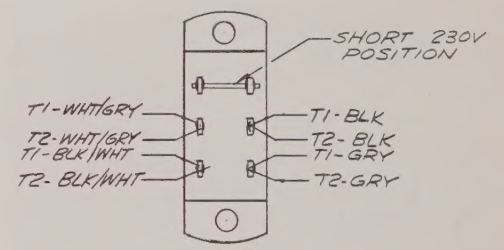

SW2

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO	QTY
1		TRANSISTOR BD ASSY	WAVETEK	D154-017	1
2		REAR PANEL		C154-302	1
3		TRAN BD SUPPORT		B154-312	1
4	T1, T2	TRANSFORMER		CM2-500	2
5		MICA INSULATOR		B154-314	1
6		END BELL	WAVETEK	110-333	2
7					
8					
9					
10		FUSE HOLDER	LITTELFUSE	342012	1
11	F1	FUSE ½A (115V) STD		313-500	1
12	F1	FUSE ¼A (230V) OPT		313.250 1S	
13	SW2	SWITCH (SOLDER GUARD)	SWITCHCRAFT	46256LF	1
14	J1	POWER RECEPTACLE		AC3-G	1
15	J4, J5	BNC	KING	KC7946	6
16		SHOULDER WASHER	H.H. SMITH	2668	12
17		SOLDER LUG		1497	6
18		SOLDER LUG		1414-4	1
19					
20					
21					
22					
23					
24					
25					

rev	ecn	by	date	app.
B	485	BC	8/27/72	
A	401	PB	2-1-72	

tolerance unless otherwise specified .XXX ± .010 .XX ± .030

scale N/A

material N/A

finish N/A

WAVETEK san diego, calif

by BOCHICHIO date 8-17-71 app. K.S.F.

title REAR PANEL ASSY

model no. 154 | dwg no. D154-001 | rev B

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MP MASTER
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